Users' Performance of Accessible Sound-Only Computer Games

A Thesis submitted to Middlesex University for the Degree of Doctor of Philosophy

by

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Abstract

The design of sound-only computer games is the primary focus of the present work. Sound-only games represent a significant theme in the development of accessible games, aimed at providing a very important contribution for users with visual difficulties, those for whom vision is not a viable option and those who simply like the challenges of sound-only games. Computer games are potentially useful to explore the generalisability of HCI findings in work or task contexts. They can also be used to measure human factors, such as emotion, feeling and creativity. Accessibility in computer games design is highly important to the extent that it allows different groups of users with different disabilities who would otherwise be unable to enjoy them fully. However, it is often a difficult and unrewarding task to design and develop an accessible game, as demonstrated by the fact that very few such computer games have been successfully developed based on concepts aimed at user learning and accessible games used by disabled users. In particular, users who are blind or those who have visual limitations form a substantial group of potentially disadvantaged game players. This research has also proposed the user sensitive inclusive design method to inform game designers and practitioners to pay more serious attention to user diversity when designing a good game.

This work is conducted at two levels to meet the requirements of this research. The first objective is to develop a better understanding of how to design better sound-only games for a wide range of users. A new theoretical framework has been crafted to achieve this objective (Human Understanding Theory of Novel Games with Simplex, or the HUNGS theory). Such a theory aims to capture the current consensus about user requirements (as far as it is possible to do so) whilst understanding the principles and practices of interactive systems, namely the design of accessible sound-only games. The second objective is to understand better the psychology of intended users of such games. The importance of the present work is to test psychological concepts in the very different and very popular context of computer games. Implications found for users at work or working on serious tasks may not generalize to game players. To achieve the second requirement, a number of existing games were explored before a

new game was designed (namely the Totally Lost game), using a range of methods. The Totally Lost game and different versions of the same game have been designed and evaluated based on user experiences.

The game was tested based on the concepts of cognitive overload and the learning curve, stress and dual-task performances. It turned out that different players' data produced differently shaped learning curves, reflecting different regression functions. These are surprising and interesting results, raising the intriguing possibility that difference functions could provide diagnostic measures of user performance and experience. The present data supported the view that such differences were due, in part, to variations in motivation. Such psychological metrics, along with a newly crafted set of heuristics (based on user's feedback and questionnaires) will be used as a guideline for user interface evaluation and to provide simple guideline to develop and evaluate good game design. The heuristics designed in this research will act as a potential checklist for the Totally Lost games designed to avoid most common game problems encountered by game players. In this research, they were used to guide the design of "Totally Lost". The heuristics were first used to test against the Totally Lost 1 game to produce better versions of the same game.

Games enjoyability was found to relate to an optimum level of cognitive overload. A truly enjoyable sound-only computer game is a game that contains an optimum amount of cognitive overload. The present findings are consistent with the conclusions that game players' learning curves are important to determine the enjoyability of the game. Highly motivated participants were successfully predicted to show exponential learning curves in the last experiment, whilst less motivated participants showed power or linear functions. Linear functions were also produced by combining data, whilst exponential and power functions were found in the non-aggregated scores of individual players. So, this research has also combined the traditional psychological principles of evaluation with traditional HCI methods; the so-called universal power law of learning was investigated through regression analysis. This power function may sometimes be replaced by linear or exponential laws that could not be explained as an artifact of averaging. Clearly, the power law of learning does not apply universally and that exponential functions often predominate, particularly with well-motivated players with truly enjoyable computer games. If so, cognitive load and the learning curves can provide invaluable diagnostics of the user experience that do not rely on user frankness or awareness.

Preface

I can confirm that this thesis is my own writing and includes nothing that is outcome of work done in collaboration. This work has not been previously submitted or published at any other university for any degree or other qualifications.

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Contents

Chapter 1

Introduction

1.1 Research Scope and Question

Computer game design is important for at least three reasons. First, games form an increasingly large proportion of current computer systems. This explains why computer games are one most popular and recent form of research by most researchers (in CHI workshop 2010). One growing topic is games accessibility (Ossmann and Miesenberger, 2010). Second, computer games provide a distinctly different context within which to understand user psychology. Games could also stimulate the development of cognitive skills (Pagulayan and Keeker et al., in press). Third, computer games have lagged behind other types of systems design for accessibility and present significant accessibility challenges, including design for players with disabilities such as visual impairments. This research also aims at providing visually impaired and blind people, and those who simply like the challenge of accessible computer games with better access to computer games by developing different types of sound-only games, based upon experiments to evaluate the effectiveness of sound cues, providing new strategies, guidelines and principles for a better understanding of the importance of sound as an output in different game interfaces. The contribution of this research will be able to assist game designers and practitioners to produce an effective and interactive sound-only computer game.

Another aim is to develop a new psychology theory to provide a conceptual basis for emerging findings (HUNGS: Human Understanding Theory for Novel Games with Simples) and to provide a guide to design a systematic sound-only game. To do so, two psychological metrics have been proposed; cognitive overload and learning curve.

The two metrics will help to understand (a) game performance and experience, along with the use of dual-task performance to understand user performance at different stages of learning and (b) how to optimize cognitive overload (and under load) for game players with visual difficulties when playing such accessible games. Player motivation levels and their learning curves have proved to be influential factors for this research. For example, Experiment Eight (in Chapter Six) studied motivation of the individual player, to explain player motivation and the significance of the shape of their learning curves. As predicted, highly motivated players produced the exponential learning function rather than the traditional power law (Heathcote, Brown and Mewhort, 2000) in the present context of sound-only games. The final outcome of this research will contribute to produce a clearer statement about the user psychology and sound-only computer games, and will emphasize the effectiveness of sound either in the game environment or in the real world context, such as producing an understanding of cognitive overload and strategies when designing sound-based systems.

To achieve the research aims at contributing in sound-based systems, sound-only games were chosen since they represent one significant context for accessible systems, aiming at visually disabled users, those in contexts where visual input is not helpful and other computer users who simply like the challenge of it. Of course, auditory-only presentations may prove to be more difficult to learn (Hinds, 1999) when compared to visual environment (Cullbertson, 1973) as it may provide heavier cognitive load. Furthermore, designing accessible games is usually a difficult and unrewarding task. Very few such computers games have been developed that satisfy their user groups. In particular, users who are blind or who have visual limitations form a substantial group of potentially disadvantaged game players (Archambault, 2004; Furth, 2008). More accessible games that could be used happily by users with such disabilities need to be designed (Archambault and Gaudy et al., 2008).

Some benefits of playing sound-only games may include training and assisting people with visual disabilities to improve their skills of spatial navigation, sound perception and memory. Other benefits include the promotion of enjoyment that would allow them to avoid or recover from stress (Lally, 2002) in the workplace. Apart from those benefits, computer games provide a realistic and ecological valid way within which to investigate positive user learning, experience and performance (Lowood, 2008). Standen and Cromby (1996) have reported that a truly accessible computer game could have encouraged and increased the learning of disabled learners' when participating in online grocery systems. More ambitiously, the outcomes from game playing may generalize to the real-world. For instance, walking to the bus station in the real world can be considered as very similar to controlling a game character to the bus station in the in-game world. They both require the acquisition of similar cognitive skills from the user.

The attractiveness of accessible games has now reached an extent where it has increasingly attracted the interest of game designers to compete in creating more enjoyable accessible computer games for people with disabilities to use (Savidis, Grammenos and Stephanidis, 2006). Such computer games will not only aim at providing resources for anyone with visual disabilities, but also for those who simply like the challenges of sound-only games. However, the specific design details of accessible games are very important (Buaud and Archambault et al., 2003), since they impact on the interactivity of the game and on the quality of user experiences. Buaud and Archambault et al. (2003) also suggest that learning quickly in a game context is important to enhance a player's experience. However, learning more slowly when playing computer games could also motivate slow-learners (particularly female slow-learners; Steiner, Kickmeier-Rust and Albert, 2009) to explore the game thoroughly and interactively. Clearly, this usually depends on what the user prefers. Therefore, it is very important to design a game on the basis of user requirements. User sensitive inclusive design should explore both the design and the user (Newell and Gregor, 2000; Otjacques and Krier, 2010). Perhaps merging the user sensitive inclusive design for user evaluation, psychological approaches and HCI evaluation design method could contribute to reveal the secrets of the creation of a good game?

In summary, the sound-only game has been chosen in this research for at least two reasons. First, in many settings, visual presentation is either impossible or inadvisable for people with visual difficulties or limitations of context. Second, sound-only games provide an ecologically valid way to investigate human auditory perception. In computer games, sound is an extremely important feature that allows the player to completely engage in the game so they could fully enjoy playing it (Chandler and Chandler, 2011). Visually impaired and blind computer users are an important part of the population but are poorly supplied with accessible games. This is particularly striking as computer games have now formed one of the most popular (Vickery and OECD, 2006) and challenging accessibility applications (Ossmann and Miesenberger, 2008) of the information technology. As a result, people with visual disabilities could become expert game players if their games are carefully designed, since participating in the game play will more likely generate a much stronger sense of presence when compared to merely observing games (Tamborini and Eastin et al., 2004).

Small companies are currently beginning to expand their development to built better sound-only game interfaces so they could improve the production of accessible and interactive games for these groups of users (Andresen, 2002). Game developers have also called for sets of quality criteria to enable them to enhance their computer games in order to create truly accessible games. An existing study (Targett and Fernstrom, 2003) found that playing sound-only games helped players to enhance their cognitive skills such as their memory and ability to concentrate when perceiving precise information. On the other hand, playing sound-only games will provide several benefits such as expanding player's spatial freedom in perception (Drewes et al., 2002; Targett and Fernstrom, 2003; Rober and Masuch, 2005). Here, they will have more freedom interacting with different sound cues in the intangible sound-only game world and thus in the real world too.

A psychology theory (human cognitive architecture), namely the HUNGS theory has been proposed in this research. The aim is to create a cognitive architecture that captures important and relevant aspects of human cognition in a games context and that also assists designers and practitioners in the design process; it provides underlining human principles in the design structure (Rodriguez and Galvan et al., 2010). Such a theory will help to capture insights into human cognitive processes that will contribute to the critical understanding of user performance, as the target audience in design. Current research has reported the combination of psychology theories (Sweller, 2010) and HCI could explain so much more about cognitive processes, particularly in human thinking and knowledge. Based on the HUNGS theory, a set of heuristics has been crafted to provide better capture of user and sound-only game performances. The theory is further discussed in Chapter Three.

The accessibility and enjoyability of an interactive sound-only game should be based on both user satisfaction and game performance. A set of questions were crafted based on the principles of the HUNGS theory. These forms were distributed to every player to fill out after playing the game. The questions in the form were turned into sets of heuristics to provide the best capture of user requirements, as a basis for user satisfaction. Usability heuristics and game-play design heuristics are both needed. Computer game heuristics that are based on task-based research that only focus on the usability principles of the game and not on the game-play dynamics that enhance game performances (Desurvire and Wiberg, 2009), might completely miss the interactivity, challenge and enjoyability of the computer game.

Existing research (Park and Hwang, 2009) found some predictive methods to explore the enjoyability aspect of computer games addiction. They suggest that their investigation has captured some addictive features of game playing in immersive computer games, such as user experience and user feelings. Other existing basic approaches proposed to evaluate enjoyability of computer games (Taylor and Backlund et al., 2009) includes learning (Koster, 2005), competition (2003), the application of design heuristics (Desurvire, Caplan and Toth, 2004), narratology (Murray, 1998) and ludology (Eskelinen, 2001). Sound-only computer games are accessible games that convey only sound cues to the player. If so, does this mean that users require greater concentration when playing sound-only computer games when compared to normal computer games? Could similar concepts used to evaluate enjoyability in all types of computer games?

In summary, this thesis aimed at two important research questions. First, how can we best design accessible, sound-only games for users who are blind, visually disabled, in limiting circumstances or simply like such games? The methods employed have shown a transition from concept based design, to user-centered design and to user sensitive design. Finally, the work has brought together both the cognitive psychology of the user and HCI methods. Second, this work has explored the psychology of the game player and found diagnostic measures to assist in this work. In particular, the role of cognitive overload / under load and learning curve functions has be shown to have diagnostic value for both game designers and researchers in this field.

1.2 Motivation for this Work

Today, the interactive aspects of computer games have stimulated a substantially rapid growth in this source of entertainment. Computer games now form one of the biggest categories of software applications in the world today, as an evident by the ESA (2007) when most American households play computer games as part of their leisure. Such potential system have emerged as a major entertainment industry by exceeding total yearly sales increasing in range from millions to billions of dollars (Price, 2002) and forecasted to be 46.5 billion dollars (spent on computer games) by year 2010 (Kolodny, 2006). As predicted by Collins (2008), this figure is expected to increase significantly every year. Given the popularity and attractiveness of this area and the considerable development potentials of different game companies, many researchers, including HCI professionals, have proposed new approaches to create positive learning and user experiences (Jorgensen, 2004) for different users when playing games they developed. Yet, most computer games still involve the graphical user interface and that is, of course, only acceptably accessible for sighted and low vision users. So, the design of accessible games and sound-only games provide one significant theme that provides opportunities for game researchers to focus their work.

The evolution of different technologies in the computer game market has expanded in the gaming industry, turning games into more sophisticated interactive entertainment systems when compared to other industries, such as music and filming companies (Marks, 2001). If computer games require greater cognitive skills and provide more cognitive stimulation (Lieberman, 1998), this might imply that they are more entertaining compared with other entertainment media. Computer games have spread widely and were recognized as more than mere fashion technology. Vorderer and Bryant et al. (2006) reported that the sales of computer games software increases exponentially every year. Many computer users demand games as one of their essential entertainment applications. This consideration throws up computer games as an important new content area of technology. Today, computer games are played by diverse users across different ages, ranging from children to older adults and across different cultures. King (2002) concluded that computer games have became a central part of most people's leisure. If so, computer games have gained substantial popularity in society. It is predicted that computer games will earn a lot of revenue over the next decade (Collin, 2008). This prediction suggests that computer game technology is moving rapidly to a stage where most people treated it as a necessary part of their lives. However, most game designers only consider visually based games and do not tend to include visually disabled users in their expert user groups when dealing with new computer games. Most blind users do not have the capability to gain access to mainstream computer games (Friberg and Gardenfors, 2004). So, designers have started to include the concept of inclusive design in their design process (Keates and Clarkson, 2003). Hopefully they may soon start to produce accessible games that offer equal opportunity for diverse users (Furth, 2008).

Finally and more critically, there are at least four reasons for choosing computer games as the medium of testing in this research. First, computer games are more interactive when compared to other electronic pursuits. Computer games will provide challenge and excitement to most computer users who play them (Beedle and Wright, 2006). Second, it is by no means clear that the results of studies in work-related or other contexts will generalize to computer games. Third, computer games are intrinsically interesting as a venue to study human cognitive performance and skills. Forth, computer games may motivate different cognitive skills (Hartmann and Klimmt, 2006). It is an effective method to explore cognitive processes (Durkin, 2006).

Durkin also found that "the frontal lobes are still maturing during adolescence and a range of executive functions, working memory, and metacognitive strategies continue to develop. Computer games engage these capacities" (p.418). If game players notice they have not acquired sufficient skills to perform well in the game play, they will work harder to attain such skills. In other words, playing computer games may help to improve user's computer literacy (OECD, 2007). If so, designing accessible games could become even more worthwhile and profitable undertaking.

1.3 Research Background

Since the earliest development of modern computer games around 1958, computer games have achieved significant popularity with people, both children and older adults. The computer game here defined as games with general game rules and regulations applied (Salen and Zimmerman, 2004). Playing computer games will provide its users with fun and pleasure. Most importantly, playing computer games may contribute to learning (Shaffer and Squire et al., 2005) and to the development of critical thinking skills. This is evident in the work of Qian, Zhang and Jin (2010) in their case study. They found that game players will not able to divert their attention to other tasks whilst they set their focus on one game. The computer game is usually recognized as a learning tool (Akilli, 2006) though sometimes it may produce various negative effects for some computer users (Greenfield, 1994). However, in many cases, game players could enhance their perceptual skills positively through games (Greenfield, Brannon and Lohr, 1994; Greenfield, Camaioni, et al., 1994; Okagaki and Frensch, 1994; Greenfield and Subrahmanyam, 1994; Buckley and Anderson, 2006; Lee and Peng, 2006; Ritterfeld and Weber, 2006; Chudacoff, 2007). Game players will often develop creative thinking skills as a basis to build new strategies to win games. Most expert researchers suggest that computer games are powerful learning tool (Wang and Guo et al., 2010). Most children engaged in mathematical computer games as a part of after-school activities, treat the game playing as providing additional learning opportunities (Battista and Clements, 1984; Clements, 1987; Yelland, 1999). Many parents would support their children to use computer games to revise for their studies, as reported by the Entertainment Software Association (ESA). More importantly, people who engaged with computer games will often develop improved mental abilities and cognitive skills (Gunter, 1998), such as critical business skills and strategies, particularly in teamwork management and other professional attributes such as decision-making, risk-taking and leadership skills (Beck and Wade, 2004). In summary, the development of computer games has not only promoted learning, but also stimulated user enjoyment (Wood and Griffith et al., 2004). The Interactive Entertainment Association of Australia (IEAA, 2005) has also predicted that the growth of computer game players will increase more significantly in the next decade. Interestingly, this growth rate relates to increasing levels of children's socialization (ESA, 2007).

Cognitive overload is defined as excessive but essential or unavoidable information presented to users that exceeds their cognitive capacity (Mayer and Moreno, 2003). Cognitive overload is taken seriously because it causes various cognitive consequences, such as frustration, complication, stress and pressure for the users. The concept of cognitive overload has seen a substantial resurgence of research activity as it is deployed to underpin new insights into cognitive augmentation (Adams, 2006; Schmorrow, Stanney and Reeves, 2006). In work environments, cognitive overload is often seen as a negative factor. For example, various palliative actions such as music therapy with soothing music (Synder and Chlan, 1999) have been introduced. However, the concept of cognitive overload in the gaming context is not necessarily a negative concept. It may sometimes have a negative influence in computer games playing if the overload level is not optimized appropriately (Hinds, 1999; Clarke and Duimering, 2006). Perhaps, cognitive overload is not always bad in the context of computer games since cognitive load could be experienced as additional stimulation in computer game that enhances game performance and player experience (Ang, Panayiotis, Zaphiris and Mahmood, 2007).

Cognitive overload in computer games has been studied by psychologists and usability specialists. Feinberg and Murphy (2000) conclude that users would be able to concentrate better if a system integrates visual and sound elements into one overall representation. If so, it should be an effective way to reduce the cognitive overload effect. Previous studies (Broadbent, 1975; MacGregor, 1987; Baddeley, 1998; LeCompte, 1999) have argued for the conclusion that the capacity of working memory is limited. If working memory could only process a few chunks of information at a time, then cognitive overload may impair both working memory (Miller, 1956) and learning (Kalyuga, Chandler and Sweller, 2000; Mayer 2001). In computer games, concentrating on too many sound cues and complicated animations may result in cognitive performance decrements due to the enormous amount of extraneous load presented at the same time (Paas, Renkl and Sweller, 2003; Mayer, 2005). If most game players treated computer game as a stress-reliever tool, even if they have to concentrate too many game elements, how could they make good decisions and think critically before making such decisions in game play? Would any overload be experienced as additional stimulation (game challenges) that could provide enhanced excitement, or, alternatively, have the opposite effect? Kalguya and Chandler et al. (2004) suggest that heavy processing demands in working memory would reduce the efficiency of information processing system. If so, the overload effects are less visible if the task is well practiced (Newell and Rosenbloom, 1981)?

Sound is very important in most media entertainment industries such as, computer games, digital books, GPS systems and other multimedia presentations that deploy sound and music to increase the user's immersion. Immersive systems often provide extensive user experiences to allow them to attain maximum pleasure from these media. In movies, sound can be used to enhance interactivity and the presentation of realistic phenomenon to their audiences. Audiences will feel afraid when watching horror movies due, in part, to the sounds provided in the sound-track. In fact, horror movies are deploying "creepy" sounds (Hutchings, 2004) to shape their audience's attention, perceptions and responses. Similar to movies, in game environments, player will usually return to engage regularly in the game if game systems provide significant challenges and realism. The outcome will also contribute to a better learning progress (Schuurink, Houtkamp and Toet, 2008). Their work also suggests that sound is often one of the main contributors to user-game engagement. Therefore, a good game always reflects its level of enjoyability and that enjoyability is an important component of good game design.

Sound is a very important and effective element in game user interfaces. Sound should assist users; in their auditory perception (Mereu and Kazman, 1997), information literacy (Galarneau and Zibit, 2006), providing adequate acoustic information (Korhonen, Holm and Heikkinen, 2007), giving immediate feedback (Friberg et al., 2004; Amarasingham, 2007; Microsoft, 2007), enhancing the user experience (Archambault and Ossmann et al., 2007) and conveying non-visible information to the user (Gaver, 1989). The importance of sound cues in interactive systems has now reached a stage where high quality sound is essential if a system is to provide acceptable levels of realism to the user. Most interactive systems such as computer games or other system interfaces rely heavily on high quality sound (Pardew et al., 2004). These are the factors that explain the importance of sound such that interactive system designers should not omit high quality sound from their systems (Archambault and Ossmann et al., 2007). Entertainment such as playing computer games is clearly less interactive without the presence of sound.

As technology evolves, games accessibility became a hot topic for most game designers. Accessibility in computer games is extremely important for many people. In fact, accessible games are very important if people with visual impairments are not to be excluded from computer entertainment (Archambault and Gaudy et al., 2008). Accessibility has the potential to allow these players to play the game independently. Computer games are important for users for the development of their cognitive processes (Chang, 2003). If they critically engage in these activities (Libby, 2002), then computer games deserve to be well promoted. To date, many people with various perceptual, cognitive and psychomotor disabilities and impairments cannot access interactive multimedia applications. In particular they have difficulties accessing such applications with a computer mouse and through graphical user interfaces (Buaud and Archambault et al., 2003). So, game designers are working to redesign the parameters of computer games so that they could potentially allow all game players to participate (Grammenos, Savidis and Stephanidis, 2007) including people with cognitive impairments (Adams, 2007; Keates, Kozloski and Varker, 2009). Initially, when the concept of accessible computer games was introduced, most game designers encountered difficulties when trying to design them. In fact, accessible games often difficult to design. Therefore, the game designer faces even more serious problems when trying to develop interactive and enjoyable computer games with sound-only content. Some researchers (Raisamo et al., 2007) have proposed multimodal applications and suggest that those applications are ideal for many disabled users. Multimodal applications are applications utilizing multiple input and output media (Ilmonen and Kontkanen, 2002) in its interface, including systems combining visual, auditory and tactile cues. Tsuhan and Rao (1998) indicated that this multimedia integration could be more beneficial than interfaces containing only one modality.

Sound-only games are becoming a serious alternative to 3D visual computer games, except that these games will only convey information acoustically (Friberg and Gardenfors, 2004; Rober and Masuch, 2005). Generally, sound-only games are targeting at anyone with visual disabilities, those whose vision is not a viable option or those who simply like the challenges that they provide. Visually impaired users are increasingly becoming expert computer users judging by their emerging widespread computer usage (Nicotra and Bertoni et al., 2010). However, since they could not perceive visual information on screen (Archambault and Gaudy et al., 2008), the auditory-only interface is a profitable alternative for people with vision impairment (Magennis and Gallagher et al., 2003) if they plan to gain access to new technologies (Marl, 1999). Therefore, this is one of the main reasons that sound-only games are usually tailored-made for visual disabled users.

The success of a computer game reflects at least two factors; the design of the user interfaces and game play. However, what exactly is game play? Salen and Zimmerman (2004) explained the term "game play" by separating the two different words. 'Game' is an objective or activity whilst 'Play' refers to a complex experience produced by the game. The combination of the two separate words will explain the behavior of the game (Southey and Xiao et al., 2005) and interaction between the computer users and the computer game.

Cognitive overload is often perceived as a bad influence in most contexts. However, in the gaming context, the concept of cognitive overload may be related to increased stimulation and could enhance learning. It has also been suggested that sound presentations require more cognitive process and thus produce overload, though some researchers have argued that the reverse is often true (Hinds, 1999). If the negative consequences of cognitive overload are influential in sound-only games, then learning would be expected to slow down due to factors, such as fatigue or failure to compensate (Wilkinson, 1962). However, the presentation of cognitive overload in games does not necessary relate to a failure of performance or learning. Perhaps there are differences between traditional laboratory studies and investigations of computer games such that the findings of the former would not apply the exact same way to sound-only games context? If so, the cognitive overload effect could actually motivate the player by creating effects that are challenging and enjoyable game aspects that may even protect the game performance. Of course, challenging and enjoyable games are good games that are designed. On the basis of different consequences of cognitive overload, the effects of cognitive overload could be better understood.

Vanderheiden (2000) suggests that a good system should be built with simplistic content and interface. This could certainly avoid cognitive overload. However, most computer games offer different levels of difficulty. Different levels of difficulty represent the challenges of a good game. Some researchers suggest that practice will increase performance rate (Loh, 2008) and improves the rate of learning (Newell and Rosenbloom, 1981; Rosenbloom and Newell, 1987). If practice over time increases user performance, then learning reflects what remains to be learned. This concept should apply to playing sound-only games. So, if learning slows down, during a game, then the use of difference game levels could be used to motivate game players to keep learning and playing, even by increasing cognitive overload again. On this view, cognitive overload should be optimized to sufficiently retain the challenging aspect of a sound-only game, and this feature should be important in the design of all types of games.

Cognitive disability is an extremely important issue which determines the progress of the development of the accessibility of our future technologies (Cherry, 1953; Pinker, 1997; Adams, 2005a, 2005b, 2007). Interestingly, many researchers explore different methods to allow diverse users to gain better access to technologies. Some uses psychology theories (Shneiderman, 2003; Adams, 2007) to explain the underlining difficulties most users have with interactive systems. Although psychology theories are useful, they work well in explaining cognitive processes accurately and but could sometimes completely miss some important accessibility features of an interactive game system. Clearly, accessibility (or e-accessibility; Adams, 2006), universal access and design (Stephanidis and Savidis, 2001) and inclusive design (Adams and Langdon, 2003; Keates and Clarkson, 2003) for computer technologies is important. But first, game designers should understand basic HCI issues and users with different cognitive skills (Adams, 2007) when developing an accessible system. This should provide them better capture of user's needs since "the knowledge of human, of his behaviours, reasoning and representations, must be at the heart of design: in the process of design, the engineering must be centred on the human" (Rabardel, 1995, p.239).

There are at least two types of visually disabled users; visually impaired people and blind people. Visually impaired people refer to people whose vision are low or severely reduced, and could be corrected partially at least within glasses. Blind people on the other hand have a very high degree of vision loss. They usually could only tell the differences between light and dark (Hicks, 2007). However, there is one small proportion of blind people who could not even recognize lights. They are totally-blind people.

1.4 Outline of the Thesis

This thesis comprises eight main chapters (excluding references and appendix), and will be as follows:

Chapter One: Introduction

Chapter one formally introduces the proposed work and provides reasons as to why this research is necessary. This chapter will briefly outline the motivation and background of the research, along with some brief explanations of what is the outcome and contribution of the thesis.

Chapter Two: Literature Review

Chapter two reviews the literature of the most relevant and existing investigation of the research area. The literature review highlight some important research areas, including auditory interfaces and sound-only games, relevant theories related to the concept of cognitive overload, user learning and performance. It also explains how existing research overcome some of the design problems relevant to the concept of usability and accessibility, as well as limitations of findings from the literature.

Chapter Three: Human Understanding theory for Novel Games with Simplex

Chapter three introduces the fundamental understanding of human cognitive architectures and concept of the Human Understanding theory for Novel Games with Simplex (or HUNGS). This includes the background of simplistic theories, the formation of the HUNGS theory and how its structure contributes to sound-only games design. This chapter also describes the contribution of the theory and the production of heuristics as a guide to assist audio game designers and practitioners to evaluate sound-only games design and to develop a more effective and enjoyable accessible sound-only game for blind users.

Chapter Four: HUNGS Heuristics: Principles and Guidelines

Chapter five proposes a set of heuristics for sound-only games and the evaluation of these games with expert evaluators. Six valuable evaluators are professional game evaluators (two blind expert users, two professional musicians with absolute pitch and two sighted professional computer gamers). They were asked to evaluate the game based on the HUNGS theory and heuristics.

Chapter Five: Methodology

Chapter four investigates different approaches conducted in the experiments. This chapter was categorized into these subsections; (1) discussion of methods, (2) experimental design and (3) the sound-only games used as a subject in this research. Two performance diagnostics have been used. The purpose is to explain the significance of both the learning curve and cognitive overload in game play for different participants. The two sound-only games used in this research are also been described.

Chapter Six: Results

This chapter will discuss the overall outcome obtained from the experiments, including findings associated with different groups of participants (sighted non-musicians, absolute pitch musicians and blind people). There were eight experiments conducted with a total of seventy-eight different volunteer participants.

Chapter Seven: General Discussion

Chapter seven discusses the overall findings from this research with 138 evaluators. However, thirty-nine of them have been grouped randomly in few different discussion sessions. In summary, fifty users discussed the Drive game; fifty-one discussed the Totally Lost game; fifteen for the Totally Lost 2 game; and twenty-two participants in the Totally Lost 3 discussion.

Chapter Eight: Conclusion

This chapter will summarize the conclusions that can be drawn from the previous chapters. This chapter will present the overall contributions and highlights of this work in summary, discussing the overall research findings proposed, and other possible future research opportunities available in this area.

Chapter 2

Literature Review

2.1 Overview of the Chapter

In this chapter, previous work that is relevant to the thesis is presented. This chapter is divided into six main sections with corresponding subsections, it describe computer game interfaces and the development of sound-only games. Other relevant research areas, including the concept of cognitive overload, learning curves and the impact of cognitive overload in sound-only games will be discussed. In addition to providing an evaluation of the design of accessible computer games, particularly sound-only games, this chapter investigates user experience in such games.

2.2 Computer Games

2.2.1 What are Interactive Computer Games?

"A computer game is a game" (Klevjer, 2001).

Many people cannot specify the differences between computer games and video games. In fact, both types of games are essentially the same. They were written by similar types of programming languages (Habour, 2002). The computer game has been classified as a video game since its earliest development on mainframe computers (Grolier, 1994; Wolf et al., 2002). Morrison (2002) found that "computer games represent massive segments of the video game industry" (p.10 - 11).

Computer games are games that are played by computer users on personal and portable computers. The interactive computer game is another term used for computer games. Some researchers believe that the interactive game can best be seen as part of the multimedia applications field, combining the five interactive elements: text, graphics, animation, audio and video; (Shelly et al., 2000). However, Kim (2006) suggests that interactive computer games refers to computer games that integrate with some interactive game elements that would allow different players to engage in real-time human activities, collaborating with learning experiences in the game environment. Commercial games are perhaps the most popular group amongst all forms of interactive computer games. They have become a major source of entertainment (Digiplay, 2004; Screendigest, 2004). They are usually played on popular game platforms such as Playstation or Xbox (Gee, 2005).

Since the earliest development of computer games, most children have been attracted to computers so they could actively participate in video games (Harlow, 1985). Clearly, computer games are seen as important by children (Shields, 2000; Wartella, 2000). At least seventy per cent of young computer users will play computer games on a weekly basis (Facer, 2001). So, computer games have become a major computer-related activity for many children (Feierabend and Klingler, 2001). On the other hand, computer games have attracted adult computer users, too. Screen Digest (2004) suggests that the sales rate of computer games has increased exponentially, over 100 per cent in the six years from 1997 to 2003. On the face of it, computer games may have some contribution to learning (Amory and Naicker et al., 1999). Shaffer and Squire (2005) suggest that playing computer games will effectively contribute to learning.

Computer games are categorized into eight different groups (Herz, 1997; Orwant, 2001). They are action, adventure, fighting, puzzle, role-playing, stimulation, sports and strategy games. Each of these computer games genres aims to provide entetainment. For example, competition in most computer games is one important game feature for most game players (Dempsey et al., 1996) since most users prefer competing with different opponents (Klevjer, 2001), including themselves (against the time for higher game score). Most importantly, computer users have their own game preferences for the game genres that they enjoy most (Prensky, 2001).

2.2.2 History of Interactive Computer Games

One of the earliest developments of computer games, were around 1958 when the first video game creator created a game with an oscilloscope display, namely "Tennis for Two" (Williams, 2002; Montfort, 2006). The oscilloscope display is a simple graphical display machine that has been used for many years (Herman, 1997). In 1960, Steve Russell, an engineering graduate student from the Massachusetts Information of Technology programmed a game, called "Spacewar" (Graetz, 1981). He used a PDP-1 computer to build his computer game. Computer games become more popular when Ralph Baer and his employers from the Sander's Associates created their first playable game on television in 1969 (Branch et al., 2006). They had their game (e.g. the Chase game) patented. Later, in 1972, they formed a team, naming themselves the Magnavox Odyssey. In 1974, Nolan Bushnell (the founder of ATARI) developed the first tennis-based game, called "Pong". This game was based on the Magnavox Odyssey (Williams, 2002). The evolution of computer games began sometime around 1980's when popular game companies (e.g. Nintendo, Sega, Sony, Microsoft etc.) extended the boundaries of computer games, developing them in a more enriched, virtual environment (NCSA, 1995; Ng, 2007; Rehak, 2007). McGloughlin (2001) reported that the first shooting-game (namely the Wolfenstein 3D) was launched in 1992. Other popular games such as Doom and Quake are amongst the popular games, recognized as the interactive computer games introduced in that era. The interactivity of game continues to evolve, hoping that interactive computer games could excite most players so they could engage more with games. Some of the most recent interactive computer games are Counterstrike (Valve, 2007), AION and Lineage II (NCsoft, 2007), and World of Warcraft (Blizzard Entertainment, 2007). The 3D animated elements contained in these games support their rich interactivity (Kerlow, 2003). According to Nijholt, Ruederink and Bos (2009), video game companies such as Hitachi, EmSense and neuroSky will lead the next-generation games. Some of these games are now designed for mobile phones. Mobile games such as Megajump, Samurai and Angry Birds are available to be played on iPhone (Apple, 2011).

2.2.3 The Development of Accessible Interactive Games

Accessible computer games are games "developed from scratch, however, targeted merely to people with particular disability, such as audio-based games for blind people" (Grammenos, Savidis and Stephanidis, 2007, p.608).

To date, most research on computer games focuses on visual displays (Bryson et al., 1992) since vision is still considered as one of the most important sensory and perceptual systems in human psychology (Cox et al., 2004). This is also a major reason why most computer games are not accessible to all. In other words, accessibility in computer games is not entirely achieved yet (Ossmann and Miesenberger, 2010). If so, games accessibility is a hot topic for most HCI professionals and accessibility system researchers.

The accessibility design of computer games is so important and has become a major consideration for most game designers and practitioners. However, it is not an easy task to develop an accessible computer game for all computer users since designers have relied heavily on visual perception rather than on other modalities (McLuhan, 1962; Ong, 1967; Lowe, 1982). Accessible computer games will provide an entirely new direction for game developers to build a high quality interaction between users and computer games, so most computer users could gain access to these games. Obviously, the role of sound plays an important part in these games. Sound precision will increase user performances, although some researchers believe that visual cues will always be more important (Gaver, 1997).

The accessibility issue has been dramatically debated since the first accessibility problem discussed by Laurel in 1991. Laurel further suggests that "high-quality audio will actually make people tell you that games have better pictures, but really good pictures will not make audio sound better; in fact, they make audio sound worst". If accessible computer games such as online flash games on Facebook are possible (Valentina, 2008), then the interaction between the visually disabled users, sound perception and computer games is clearly not a dead issue. Sound cues are important and probably the best substitution if visual media cannot be presented well in computer game systems (Marl, 1999). If sound could provide information so accurately, and with immediate feedback (Friberg et al., 2004), then sound-only games offer valuable and important feature for game designers and developers. At the very least, sound could substitute for media-visual, providing realism and stimulation (Botting, 2008) for game players in, for example, fantasy games.

Accessible computer games are usually games designed for all groups of users, including blindness, deafness and mobility limitations (Marl, 1999). This is the reason of why the demand for such computer games is rising significantly (Bauld and Archambault et al., 2003; GA-SIG, 2004). If so, sound is very important to an extent where it could contribute in the accessibility design of games, even to reduce workload (Mayer, 2005). Some HCI professional researchers suggest some possible and effective sound-based methods to add precision to extensive game play design (Blauert, 1997; Bergault, 1994), such as the head related transfer function (or HRTF; Gardner et al., 1994), audio realism technology with the environment audio extension (or EAX technology; Creative Technology, 2002), the ambisonics technology (Gerzon, 1985; Elen, 2001) and the dummy head technology for realistic sound presentation (or binaural recording technique; Kefauver, 2001). They will make for better sound experiences, but that will just contribute partially to the design of accessible computer games.

2.3 Sound Interfaces

2.3.1 What is a Sound-Only System

The sound-only system is a term used to represent a synthesized sound system that can output digital music and various sound elements and effects (Parson and Oja, 2009). In other words, it is known as a system with a sound-only interface. Sound-only systems have gained a deservedly high reputation in most computer technologies since they provide flexible bi-directional, speech or non-speech sound, establishing connectivity between user and the system (Peres et al., 2007). One of the most popular forms of sound-only system is the sound-only computer game (NordiCHI Doctoral Consortium 2010).

2.3.2 Sound in Accessible Sound-Only Games

Today, sound and music form a realistic way of communication for blind people (Alty, Rigas and Vickers, 1996). Sound is so important (Steuer, 1992) to an extent where it has contributed extensively in the development of new sound-based systems (Edwards, 1988; Blattner and Kramer et al., 1993) and in most popular entertainment technologies, particularly for visually impaired users. The accessible computer game is one example of such technology.

The potential of sound has been explored since the mid 1800. Sound has become relatively important in telecommunication when certain auditory interfaces relied on Morse code and telegraphy (Bellis, 2007). Here, sound signals are interpreted signals acoustically exchanged between operators. Sound has become more necessary in the twentieth century when information and communication technologies (ICT) were introduced. Some ICT includes mobile phones, computer systems and other digital devices relied heavily on sound attributes. Pham et al. (2000) and Qiu, Zhang and Huang (2004) suggest that sound plays an important role in smaller screen technologies. Perhaps sound cues could convey information more accurately than visual cues for short-sighted mobile phone users. Evidence found by Rigas et al. (1999) that sound is the most productive output for visually impaired computer game users. Edwards (1989) developed a sound-based word processor, namely the "Soundtrack" for blind users. He extended his research by designing "Soundtrack 2" as he believed that he could employ more effective methods to make the system more accessible. Many studies were conducted, testing with different methods to raise the accessibility of their sound-based systems (Bloyd et al. (1990), however none were proven to be sufficient. This may be due to the incomplete nature of research on the accessibility of different interactive systems incomplete.

In many settings, sound could provide accessibility to complex computer systems (Gaver 1986, 1989; Gaver, Smith and O'Shea, 1991), such as games, but how is this done? Sound presentation is effective when conveying information to the user (Peres et al., 2007) since it could present essential information to the user when visual cues are not available (Benette, 1999). With sound presented over the game, the game players do not need to worry about missed opportunities. This explains the effectiveness of sound in sound-only games (Vadas et al., 2006). Part of the importance of sound is the potential to help reducing game players stress level (Bergault, 1994) when compared to other modalities such as visual presentations. For such, visual displays increase overloads when publishing redundant or irrelevant information (Mountford and Gaver, 1990). If so, then complex computer systems such as accessible computer games should consider substituting some visual cues with sound to overcome overload issues. Buxton (1989) suggests using sound cues to assist blind users in user interfaces. This could solve some of the current cognitive overload problems (Schnotz and Kurschner, 2007).

Sound can be perceived in different dimensions (Darvishi et al., 1994) such as pitch, timbre, amplitude, tone, etc. (McGregor et al., 2006). They are usually used in different sound-based interfaces. Most importantly, sound presentation can provide a greater sense of realism (Blauert, 1997; Larsson, Vstfjll and Kleiner, 2001) and increase the accuracy of information provided for the user. This statement has been supported by substantial earlier research (Belton, 1992; Boer, 2003), examining sound identification (Bly, 1982; Rossing, 1990) and attention in human (Jones, 1989), speed of sound perception in human (Bly, 1982) and sound perception and accuracy (Wenzel, 1992). In fact, sound perception changes, depending on the air vibration by ear (Steuer, 1992). The relative merit of sound is that it could allow blind people to gain access to the same information as sighted people (Mynatt, 1992). This appears to be something very beneficial for most computer users since high-stress in game environment will result in losing awareness in the game environment (Nijholt, Ruderink and Bos, 2009).

Accessible sound-only computer games are an important subset of computer games, building with sound-only elements. Some learners simply prefer listening to sound cues rather than reading visual cues (Sticht, 1971; Coady, 2002; Vadas et al., 2006). It seems likely that sound could provide immediate feedback to users when compared to reading text (Amarasingham, 2007; Microsoft, 2007). This is also a reason to think that sound could effectively support different learning phases (Gaudy, Natkin and Archambault, 2009).

2.3.3 Games for Blind People

The number of blind people increase everyday (RNIB, 2011). Most game designers took this opportunity to design enjoyable computer games for blind users so they could join to have fun in the video gaming (Adams, 2005). Such a game is known as the accessible sound-only games, or audio games.

Computer games have remained inaccessible since their earliest development in mid-1950 (Williams, 2002; Rober et al., 2005; Branch et al., 2006). Even the most popular 3D graphical-based computer game today (namely World of Warcraft; Blizzard, 2007) remained inaccessible for users with cognitive or visual impairments since computer users relied heavily on the presence of graphics (Gardenfors, 2002). So, the AGRIP project (Atkinson and Gucukoglu, 2004-2007) was formed, building a central focus on accessible sound-only computer games, targeting at blind users. Latter, the universal accessible theme was introduced (Grammenos et al., 2005). Their intention is to develop high-quality accessible computer games for blind users.

The creation of the sound-only games became a key of success in the development of enjoyable and accessible systems for blind users. Since then, sound-only games have been declared as a new game genre, aimed at blind user. Although there is a considerable large volume of sound-only games available commercially, yet this type of game does not receive much attention from the society. Richard van Tol, the designer of the Drive game, reported that loads of blind people have computers but not many of them know about audio games (Adams, 2005). One of the many reasons behind this may be due, partly to the public awareness. They do not understand the valuable feature of sound-only games for blind users. Such a game will also provide extensive approach towards for inclusive systems. Sound-only games could assist system designers to produce better design of potential accessible systems, if they employ similar design technique for all other accessible systems.

Today, sound-only accessible computer games have started to gain significant popularity among visually disabled users, allowing them to gain access to computer games for the first time (Bauld and Svensson et al., 2002; Bauld and Archambault et al., 2003; Friberg et al., 2004; SBA, 2006; Peres et al., 2007). If sound-only games are proved to be a successful in the development of computer games, and could resolve many accessibility computer-related problems (Bault, 2003), specifically usability issues and graphical difficulties for blind user (Gardenfors, 2002), then this group of computer users could use such games as a part of their leisure lives. Although sound-only games are games designed dedicated for users with visual difficulties, many computer game players have argued that these games could not only be played by blind computer users but also by many other interested players (Williamson, 2003). Perhaps more sound-only games could be designed and widely spread for all types of players (Roden et al., 2005), first to provide attractive interfaces (Archambault, 2002) that to avoid cognitive stress (Sanchez and Elias, 2009) and second to include sighted users in this new gaming environment.

Similar to visual computer games, sound-only computer game is playable with a computer system. Sound-only game is built entirely with sound elements. So, it will only operate with sound cues but nothing else. In other words, players will only rely on sound cues when playing it (Mendels and Frens, 2008). Since the earliest development of computer games by Atari, namely the Pong game (Williams, 2002), the popularity of such a game has invoked the creation of the first released handheld sound-only game in 1974 by Atari, namely the Touch Me game (Herman, 2008). Though this game has gained little popularity, yet most players could gain access to it. The creation of the Touch Me game has later introduced the creation of accessible computer games.

To date, sound-only games are categorized into four different genres (Gaudy et al., 2006). The four groups of games are action, exploration, stimulation and board games. There are some successful computer game organizations exploring the feasibility of computer games and needs of people with visual impairment. These successful game research companies and developers include AudioGames (2002), IGDA (2005), Westin (2004), Velleman et al. (2004), Grammenos (1989-2007), SBA (2006) and GA-SIG (2004). However, to date, there is no interactive sound-only massively multiplayer online game (MMO) available in the market. Clearly, sound-only game developers are treating such games as an ongoing project, hoping that they could resolve most accessibility challenges of such games (SBA, 2006). Of course, game designers are also working on unexplored potential of sound to increase the attractiveness and accessibility of sound-only games (Williamson, 2003). Their aim is to produce games that achieve the state-of-the-art level in design.

Two most popular sound-only games available today are Terraformer (Westin, 2004) and Drive (Tol, 2002). Other attractive sound-only games includes AudioQuake (AGRIP, 2004), Mudsplat, X-tune and Tim's Journey (TiM, 2001; SITREC, 2005), Blind-games (Blindgames, 2002), UA-Chess, Access Invaders, Game Over and Terrestrial Invaders (FORTH-ICS, 2003-2006). Some sound-focused accessible computer games (combining visual and sound cues) available for visually impaired users includes Shades of Doom (GMA, 2003), Terraformers (Westin, 2004) and Demor (Cohen and Dekkeret al., 2007). These games are developed for both research and commercial purposes. Most of the sound-only games are available for download from http://www.audiogames.net.

2.4 Computer Games and Enjoyability

2.4.1 Introduction

The enjoyability of computer games reflects the quality or performance parameters of the game that could motivate and satisfy the players. Enjoyability in computer games is an important research area that has been studied actively by different computer experts (Malone, 1984) for many decades. Malone suggests a few important game features that could contribute to the development of more enjoyable computer games. This includes multi-level game difficulty based on the user's expertise level. Yannakakis and Hallam (2007) explored the enjoyability computer games by exploring real-time user's level of engagement in games. They found that numerical values (quantitative) could capture the enjoyability of the game. The concept of enjoyability may be studied in the context of games. However, a good understanding of user interface design (Thimbleby, 1990) and users' cognitive process (psychology) may be required before understanding what makes a truly enjoyable game (Schell, 2003).

2.4.2 What Makes an Enjoyable Computer Game?

The enjoyable aspects of computer game are of significant interest for target audiences. In practice, an effective game designer usually aims at the development of enjoyable computer games. However, what builds a truly enjoyable computer game? The challenging aspect is user motivation and satisfaction in computer games. In addition, if computer users could engage in computer games such as immersive educational computer games (Kickmeier-Rust and Albert, 2010), they could develop new learning skills. For example, some video war games have been found to allow soldiers to cope better with the stresses of real combat, including a reduction of post combat nightmares (Gackenbach 2010). At least the fun aspects in computer games could motivate game players to keep learning to play. If learning speed increases without the distraction of cognitive overload (Sweller and Chandler, 1991; Kalyuga, 2007), then efficiency of computer game (without stimulant effect) could be produced. Perhaps, the notion of truly enjoyable game refers to the balancing of stimulation and overload effects (Rai, Beck and Heffernan, 2010)? Perhaps the learning functions from users' game performance could be useful to explain their enjoyability level of that particular game. This is clearly an important consideration in most computer games.

Pagulayan and Keeker et al. (2003) reported that fun and excitement are major aspects that determine high-quality performance in computer games. "I played Spyro the Dragon with PlayStation. I beat that game in three hours. Then I took up playing Spyro Year of the Dragon. I beat down that one within an hour and a half... so I was just sitting there" (Maxwell et al., 2003, p.152). However, it is not an easy task to design a truly enjoyable game by the optimization of the in-game cognitive overloads. Additionally, excessive amounts of in-game cognitive overloads may sometimes hinder the player's decision making (Page and Moere, 2007). Pagulayan and Keeker et al. (2003) and Salen and Zimmerman (2004) argued that the simplistic content of a game makes the game successful. However, how could simplistic content contribute to the challenging aspects in a computer game? If so, what are the quality criteria to produce a truly enjoyable game for diverse users? Perhaps the first important aspect of an enjoyable computer game is the in-game challenge (Clarke and Haworth, 1994; Bryce and Higgins, 2000). Bly (2004) suggests that competition is an important feature that promotes games enjoyability. Enjoyability exists if few groups of players are working hard to compete among each other to achieve the same goal. Most computer users play computer games because the game offers extensive game experiences (also called stimulation; Zerbst and Duvel, 2004). Communications between in-game players are considered to be a type of stimulation that would built closer relationships among the users (Axelsson and Regan, 2006).

Competition among other computer game players in the game world is another important feature of games enjoyability. Moreover, competing among each other will built interactions between cognitive skills development and the game. Such competencies would increase the effects of performance, joy and motivation for the players (Elliot and Dweck, 2005) and in learning (Felicia, 2009). Further support for the competitive game feature was described in the interview conducted by Sanger, Wilson and Davies et al. (1997). A female game player indicated that the computer game player gets "bored with playing sometimes. It's just the same thing over and over" (p. 144). If the game is too difficult or impossible to complete, then game players will usually quit playing the game (Rani, Sarkar and Liu, 2005).

This is why much research focuses on issues related to cognitive abilities and disabilities. They aim at the usability and accessibility of systems designed (Cherry, 1953; Pinker, 1997; Adams, 2005a, 2005b, 2007). Few famous and important concepts related to usability and accessibility of systems design has been introduced. They are the concepts of e-accessibility (Adams, 2006), universal access (Stephanidis and Savidis, 2001) and inclusive design (Adams and Langdon, 2003). These concepts are important in the design of an enjoyable computer game since the property of cognitive overload is usually link to enjoyability (DeHaan, Reed and Kuwada, 2010) and user game experience (Ang, Zaphiris, and Mahmood, 2007). The effects of cognitive overload may provide completely different results in computer games playing when compared to work contexts (Adams, 2006). Overall, an effective computer game is usually difficult to be played since complex game elements promote different real-time aspects such as critical thinking (Southey and Xiao et al., 2005). On the other hand, a non-challenging, low cognitive load game will produce opposing effect, demotivating and discouraging the game player to play the game regularly (Raney, Smith and Baker, 2006).

Secondly, the game's interface and overall design are integral parts of the successful game. Spuy and Spuy (2010) suggest that the game design must help to make the game fun. If so, the exact design of typical computer games is important. It should also be able to address several factors, motivating the game player to play it (Klimmt and Hartman, 2006). Sound effects and interactivity of the user interface are essential components of stimulation in games design. Game features such as those that help reduces players stress and pressure should also be considered (Bowman and Rotter, 1973; Kestenbaum and Weinstein, 1985; Gackenbach, 2010). This game feature is highly important to help game players relax after work (Gackenbach, 2010). New techniques such as using various game models could help producing effective complex computer games (Spuy and Spuy, 2010). Game developers should also consider the application of cognitive psychology theories to computer games design so they could understand users' cognitive processes better (Kickmeire-Rust and Peirce et al., 2007).

The principle of user experience is perhaps a central aspects targeting at interactive systems (McCarthy and Wright 2004; Hassenzahl and Tractinsky, 2006). The HCI (human computer interface) approach, is one of the most important approaches chosen to build the success of computer games design (Desurvire and Wiberg, 2009). To date, productive and accessible computer games have been measured by effective usability approaches. One such an approach is heuristic evaluation. Heuristic evaluation, a well-recognized inspection approach by relevant experts for system design has been introduced by Nielsen and Molich (1990) and Molich and Nielsen (1990) and can assist system designers to understand their user experience more in depth.

Heuristic evaluation has formed a long and traditional HCI evaluation technique. There are many types of heuristics since the initial set was proposed by Nielsen and Molich (1990). Malone (1982) first uses a set of heuristics to evaluate instructional computer games. There are evidences where a group of game designers proposed forty heuristics to evaluate the usability problem of their computer games critically (Federoff, 2002). There was another set of heuristic attempted by Falstein and Barwood (2006), aiming at computer games compiled by game designers from the game industry. Their 400 design rules' project has received numerous recommendations by many game researchers who used the guideline to develop effective computer games. Furthermore, heuristic evaluation will usually aim at computer users of all age groups, particularly developing effective computer games for children (Baauw, Bekker and Barendregt, 2005). Thus, heuristic evaluation is so important and relevant for games enjoyability. In fact, heuristic evaluation is essential as it has the potential to diagnose various usability problems (Laitinen, 2006) such as evaluating real-time user needs, so game designers could understand better the user and the game performance (Desurvire and Wiberg, 2010). It could also analyze user experience (emotion) in the context of computer games (Kersten, Tsikalkina and Bekker, 2001). This will further be discussed in Chapter Four.

2.5 Cognitive Overload

2.5.1 What is Cognitive Overload?

Cognitive overload is a cognitive psychology term used for describing an excessive amount of essential information or instruction, significantly exceeding the capacity of human working memory (mental load; Uden, 2003) when thinking, formulating and problem solving. Cognitive overload is a process of loading information into the human working memory to make sense of stimuli and consequent cognitive processes.

An enormous amount of cognitive overload usually causes disturbance to the functioning of cognitive processes, particularly decision making (Stokes et al., 2001; Tepas et al., 2001). Hillier et al. (2006) suggest that cognitive overload is a cause of cognitive stress, impairing cognitive flexibility.

Cognitive overload has a long history and substantial current research activity. Initially the concept of cognitive overload has been developed in the long-running field of environmental stressors, including noise, heat, sleep deprivation and circadian rhythms (Broadbent 1971, 1984). Early work had demonstrated the conditions under which these stressors could impact human performance, namely the need of sustained concentration overtime (Wilkinson, 1961; Wilkinson, 1962; Hartley and Adams, 1974). However, explorations of the interactions between stressors have demonstrated that explanations in term of simple one-mechanism decrement in performance would not suffice. This has been continuously explained in the two mechanism theory of Broadbent (1971).

2.5.1.1 The Concept of Arousal

"Arousal is a hypothetical construct that represents the level of central nervous system activity along a behavioural continuum ranging from sleep to alertness" (Razmjou, 1996, p. 530).

The concept of arousal plays an important role in the understanding of cognitive overload and performance. According to Gaillard (2008), performance usually decreases due to stress effects (or overload). Obviously, the arousal of stress is serious in cognitive processes. There are four main groups of stress types and arousal (Hockey, 1986). These effects will subsequently impact information processing, and that everyone may wish to avoid. Please refer to figure two in the appendix 9.2 for a clearer depiction of the effects of arousal on human information processing.

Honeybourne et al. (2000) reported that a person will normally lose consciousness if aroused excessively by the amount of essential information presented. Such an information load is considered to be an extreme of cognitive overload. This has been further explained by Broadbent (1971) in his book entitled "Decision and Stress". The two-mechanisms explained in this book argued that the lower mechanism could be protected from the effects of stressors by an upper, compensatory (or gating) mechanism. The Upper system protects performance of the Lower system until or unless that upper mechanism became inefficient due to fatigue or other cognitive overload effects (Wilkinson, 1962). The Upper mechanism controls performance and monitors the overall progress of the performance of the Lower system. If so, it is possible that the upper mechanism can be suggested as managing human consciousness to deliberately maintain constant performance whilst the lower determine the actual level of cognitive performance (Revell, 1995). This mechanism monitors time-based activities such as declining performance with time on task. The revised dual-mechanism can explains how motivation and the effects of anxiety and stress are often interrelated. Routtenberg (1968) has provided neuropsychological evidence of a dual-arousal system in the human brain, based on the reticular formation and the limbic system.

2.5.2 Cognitive Load Theory (CLT)

2.5.2.1 What is CLT?

Other relevant cognitive overload theories include the cognitive load theory introduced by Sweller (1988, 1990). The cognitive load theory explains deficiencies of cognitive performance when using interactive computer systems. Cognitive load is divided into three sections - intrinsic, extraneous and germane load (see below). Not all cognitive loads are negative for interactive systems design. This explains why cognitive overload should be optimized and not removed entirely from computer games.

According to Sweller, overload is divided into three types; intrinsic, extrinsic and germane load. The complexity of a novelty of the computer game is referred to as the intrinsic load. Extraneous load refers to the excessive amount of external information overloading the working memory (Chandler et al., 1991). Extraneous load will negatively impact cognition. The germane load is a process, integrating multiple chunks of information into one. It uses the automation of skilled sequences, also known as the schemata (Bartlett, 1958; Sweller, 1998). For instance, visually impaired people might feel that playing the sound-only game is easier with a computer mouse after participating in several mouse training sessions. The reason is that they have the mouse schemata set into their minds and are now able to perceive and understand the usage of the mouse immediately without any substantial learning effort. If so, all interactive systems (including computer games) should reduce the extraneous load and promote the germane load (Sweller, 2005).

Cognitive load theory aimed at the capacity of working memory (Feinberg, 2000). There are at least two components of human memory (Sweller, 1999, 2002, 2003, 2005). They are the working memory and long-term memory modules. The concept of working memory has been developed from the original concept of the short-term memory module (Broadbent, 1984; Baddeley, 1986, 1990; Adams, 2007). For example, it can store numeric information for up to twenty seconds before losing it (Peterson and Peterson, 1959). On the other hand, long-term memory is recognized as the permanent memory for knowledge. Atkinson and Shiffrin (1968) suggest that encoding information verbally is an effective method to store information in the short-term memory.

In fact, cognitive load theory was initially formed based on the chunking theory introduced by Miller (1956). He suggests that the working memory has the capability to process up to seven chunks of information at a time. In his theory, the capacity of the working memory is very limited. Only up to nine items of information could be presented (7 +/ -2 chunks). Any information presented after the ninth chunk is considered as cognitive overload. However, this principle has been the focus of a serious discussion debated over time. Some researchers (Broadbent, 1975; MacGregor, 1987; LeCompte, 1999) have concluded that working memory could store very little (three to six) items of information at a time, whilst other information is held in more peripheral buffer stores. Since the capacity of the working memory may be so limited (Sweller, 2005), many researchers (Bradford et al., 1971; Rumelhart, 1980; Mandler, 1984; Quinn et al., 1987) have performed research to promote the notion of germane load (schemata). They believed that applications of the concept of schemata could help reducing the effects of overload. The concept of schemata is important (Quinn et al., 1987). It represents a mental plan, or a set of structures used to interpret circumstantial information to solve problems. Bartlett (1932, 1958) uses the concept of schema to explain how memory works. Other experiments were conducted, and the results of the experiments have indicated that human memory is formed based on different forms of representation (Bransford et al., 1971). Sweller (1988) combined the concept of schemata in his cognitive load theory to promote learning. In short, schemata represent the combination and abstraction of information (i.e. combining visual and auditory cues) to increase human memory capacity.

However, the cognitive load theory contained a lot of loopholes. Since the cognitive load theory deals only with working memory, it is insufficient to be a complete theory of cognition that would be required to explain every aspect of cognitive overload. So, this theory requires further clarification and more attention (Brunken, Plass and Moreno, 2010). For instance, cognitive skills development and the acquisition of learning form a direct link between learning and cognitive process (and mental representation; Schnotz, Boeckheler and Grzondziel, 1999; Wallen et al., 2005). If cognitive overload and learning depend on the individual learner's potential, then the concept of cognitive load theory (Sweller, 1988) needs to be redefined to cover the wider frame of human cognition as a whole.

2.5.3 Cognitive Overload and Learning

2.5.3.1 Introduction

This section discusses the impact of cognitive overload on learning. For example, if researchers could suggest different solutions that promote the capacity of working memory, then such theories could contribute significantly to our understanding of human learning. A number of studies have investigated various solutions to overcome the effects of cognitive limitations in human learning. These approaches are important if we are to provide learners with a better learning environment. Else, it would be difficult for people to learn effectively when working under cognitive overload.

2.5.3.2 A Discussion of Cognitive Overload and Learning

Cognitive overload and stress are commonly related concepts (Mace, 2005). Both often involve a state where the consequences of overload disturb the normal functioning of cognition (Tepas et al., 2001). In general work contexts, the notions of cognitive overload and learning are related to the inverse U-curve of performance and arousal (Yerkes and Dodson, 1908). This approach asserts that performance worsens (Ritter and Schooler, 2002) particularly in learning (McGrath, 1976), due to the excessive demands of overload but also declining when arousal is too low (Driskell et al., 1996). From the perspective of brain psychology, as argued by Broadbent (1963), a singular mechanism is not sufficient to explain different stress effects. Two stress effects were investigated in a number of studies; sleep deprivation and noise (as summarized by Broadbent, 1971).

Cognitive overload can play an important role in user learning though it is important to maintain a distinction between novice and expert learners. Thus, many high quality research studies compare experts and novices in learning. They presented different overload effects in different learning phases (Pintrich and Schunk, 2002). Some existing studies (DeGroot, 1966; Chase et al., 1973, 1973a) have investigated the distinction between experts and novices in chess games. The results of their research suggest that expert players were able to memorize patterns of chess piece positions significantly better than novices. In mathematics, particularly problem solving skills, experts and novices could solve the equations but take qualitatively different approaches to do so (Simon et al., 1978; Larkin et al, 1980). They used different approach to solve the equations. Novices will use general problem solving skills, whilst the experts seem to have the ability to bypass some overload problems, recognizing or memorizing previous equation questions, using similar methods to solve the current equations more quickly. However, learning complex tasks requires both implicit and explicit learning. Overall, this expert versus novice issue is an important research question in the context of learning.

Learning effectiveness can be hindered by cognitive overload but can be mitigated by practice. After all, practice should increase learning efficacy (Ritter et al., 2002; Lucht, Domagk and Mohring, 2010). In addition, the concept of practice relates to arousal theory, referring to the regulation of human stress responses. This regulation derives from the earliest work by Yerkes and Dodson (1908). Yerkes and Dodson explored the number of trials and performance by using mice in simple learning tasks. Electric shock has been used as stress in their study to measure performance. Their conclusion was that practice could both reduce mistakes and make learning more effective (Rabbitt et al., 1980). For this reason, the Yerkes and Dodson model became a principle or the invert U-shape. Learning is equally important in computer games. It relates to increased user motivation, until a certain level when it decreases again due to fatigue etc. (Broadhurst, 1957).

Another particular aspect of learning to play computer games is the excitement interrelated to enjoyability. Ritterfeld (2009) reported that enjoyable computer games could potentially contribute to learning for most children since engagement in computer games involves training and practice. If so, an enjoyable computer game will motivate the user to learn better. Computer games and enjoyability will further be discussed in this chapter.

2.5.3.3 A Discussion of Cognitive Overload and Accessible Computer Games

Playing computer games is an important part of modern life for many people. The strategies game players use in game plays in different computer game genres, such as fantasy, challenge and curiosity (Malone, 1981), can promote effective learning. Other cognitive aspects of game playing, such as strategic thinking, decision making and communication (McFarlane et al., 2002), will contribute to user motivation, an important aspect that encourages the user to learn better (McFarlane et al., 2002).

The survey conducted by ESA (2007) found that 87 per cent of game players play computer games for fun and 72 per cent suggest that challenging computer games would motivate them to play. This motivational aspect usually refers to the complexity of the game and sometimes depends on the user's cognitive ability to play it (Schnotz et al., 2007). This is one of the reasons why computer games design is important. If the game is designed properly, this means that the game player will enjoy playing it (McFarlane et al., 2002).

It is not an easy task to calibrate computer games, especially accessible games (e.g. sound-only games) for disabled game players. If working memory has limited capacity for storing sound cues (Mayer et al., 2003), then game players may not be able to play the game properly. Not all aspects of cognitive overload need to be looked negatively in the context of computer games (optimizing level of in-game stress). For instance, due to the differential demands of working memory, children may sometimes not be able to perform well when playing games that have additional irrelevant stimulation (Lawrence et al., 2002). They could be distracted easily if the game system causes too much stress. The result may be different for expert adult game players, if they experience additional game stimulation as an enjoyable game element. A poorly designed computer game will usually present overly high-level cognitive overload for all users (Dede, 2005). Further evidence by Brunning, Horn and Pytlilzllig (2003) has suggested minimizing overload effects (mental effort) for novice users. This could help to make better use of their working memory space, since the capacity of working memory is limited. For example, it could only store information for not more than twenty seconds without rehearsal (Peterson et al., 1959). However, this will not apply for expert game players who have better memory capacity or utilisation (deGroot, 1966), so they would be expected to perform better than novice learners when solving a task (Mayer et al., 1994).

Therefore, in the context of accessible computer games, high levels of errors and confusion (Sweller, 1990; Wickens, 1992) are two detrimental aspects of enjoyable game playing, but reducing cognitive overload may not always be positively associated with game enjoyment, since higher levels of cognitive load may be more acceptable (Ang et al., 2006). This has been studied further by Chase and Simon (1973, 1973a). Ang et al. (2006) further reported that some computer games created increased intrinsic load (complexity) to enhance game play. Of course, novice learners will usually only perform moderately in such computer games (Schnotz et al., 2007). At the very least, complex games will motivate novice game players to learn to perform better. Clearly, the challenging nature of a game will determine the overall game performance.

Feinberg et al. (2000) suggest combining visual and auditory cues in order to reduce cognitive overload and to encourage users to learn more effectively. This result was further explained and validated in the dual-channels representation (Mayer et al., 2003) and existing memory theories such as Pavio's dual-coding approach (1986) and Baddeley's working memory theory (1998). For example, the combination of visual and auditory cues can help computer users to perceive stimuli more accurately (Loveless, 1957; Buckner et al., 1963). Similarly, reducing split-attention effects can be important. If split-attention effects could be avoided, the process of integrating information for comprehension purpose could be made easier (Yeung et al., 1997). Wang, Su and Yu (2010) proposed a relevant learning model for multimedia learning to improve the effectiveness of classroom learning.

Although the combination of visual and sound cues is a necessary part of the design process, it can sometimes produce inefficiencies. Mayer et al. (2003) argued that cognitive processes are sometimes one-way processes. Kalyuga (2000) suggests that the combination of text (visual) and sound is not always beneficial for learner due to the limitation of capacity of working memory. Integrating two representations at a time may increase cognitive overload and decrease performance. Can integrating information cues be beneficial in only certain learning context? Either way, this section requires further elaboration and research to explain the effectiveness of cognition and cognitive capacity in different learning contexts.

2.5.3.4 A Discussion of Cognitive Overload and Sound-Only Games

Cognitive overload and sound perception is a popular topic that has been studied by many different researchers in cognitive science for many decades (Broadbent, 1954, 1971, 1984; Mayer et al., 2003; Ang et al., 2006; Lawrence, 2006; Savidis and Stamou et al., 2007; Stephanidis, 2009). These studies provide a better understanding of perception and performance, many in the context of accessible computer games. Other relevant high quality research further clarifies the concept of cognitive overload (cognitive factors) in e-accessibility or accessible computer systems (Adams and Langdon, 2003; Adams, 2007; Stephanidis and Savidis, 2001; Huppert, 2003). Their research is aimed at computer users with different disabilities.

Sound is an important element in computer games, particularly in accessible computer games. It could effectively present information to game players (Buckner et al., 1963; Jones, 1989; Benette, 1999; Amarasingham, 2007; Microsoft, 2007). However, too many sound cues (or noise) will produce confusion (Davies and Jones, 1982). Broadbent (1971) reported that noise is a type of stress that will often reduce human performance. Such an intermittent stress (CBASSE, 1997) integrates several stress effects, such as annoyance, disturbance and unpleasant experiences that will eventually degrade the learning experience. Exceeding a particular level of sound intensity (usually around 80 and 90 decibels, also see Davies and Jones, 1982) can impair cognitive task performance (Broadbent, 1979; Oishi et al., 1999). The reason is that the capacity of human auditory channels is limited (Chandler et al., 1991; Baddeley, 1998; Sweller, 1999). If so, game player's learning experience could be affected since both activities (playing computer games and the intention of learning) are correlated (Leiberman, 2006).

Apparently, an understanding of cognitive overload is essential in accessible games design. It provides an ecologically valid way to investigate the improving game performance (learning) and game play. Keates et al. (1997) reported that users do not like using an interactive system that increases their stress level. First, a stress-free system is simpler to use. Second, a stress-free system is easier to learn. Thus, short and confusing animations may rapidly increase overload (Mayer, 2005) and this may de-motivate players. Similarly, in sound-only computer games, too many sound cues will result in overloaded cognition. Hiller et al. (2006) reported that stress due to an excess of sound cues in complex tasks effects cognitive performance. Too many sound cues presented at a time will usually decrease the efficiency of memory and attention (Matthew et al., 2000), and cause other problems such as irritation and annoyance (Langdon, 1985).

Deutsch et al. (1963) and Treisman (1964) have argued that the perception and selection of messages would depend on the importance of the message content. Wood et al. (1995) suggest that unimportant messages could be ignored by changing the key characteristics of the sound. This method should increase the intensity of important messages whilst decreasing unnecessary extraneous load (Schnotz et al., 2007). Overall, unattended messages will often be filtered (Moray, 1959), thus avoiding the overload of the limited capacity of working memory (Broadbent, 1958; Kalyuga, 1997; Hunt et al., 1999).

One effective approach to reduce cognitive overload in sound-only games is the splitting of sound cues into different chunks. This approach is known as chunking. In fact, every in-game object should be associated with a sound so the player could collect that particular item by just identifying and listening to those sounds. Sound is helpful and is an important component in computer games and improves user experience and involvement (Ivory and Kalyanaraman, 2007). Such a chunking theory could also optimize the capacity of working memory. Another approach is the merging individual sound objects into an interactive and integrated soundscape. This approach could help to solve overload problems in the context of computer games (Friberg et al., 2004).

2.6 Human Attention

2.6.1 What is Human Attention?

"Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalisation, concentration, of consciousness is of its essence. It implies a withdrawal from some things in order to deal effectively with others" (James, 1890).

Attention plays an important role in many cognitive processes. When a person distributes their attention across tasks, instead of focusing on a single task, their concentration on that single task will be limited (Cowan, 1995). Concentration on a task will also depend on the nature of the task and on the context. If so, perception of information is a reliable resource. Broadbent (1971) reported that the perception of information will sometimes depend on a concentration on specific cues. Focusing attention on one modality (for example, visual versus auditory) will improve performance with that one modality at the expense of other modalities (Broadbent, 1971; Gruber, 1964).

There are a number of popular and relevant concepts of attention including; sustained attention, selective attention and divided attention. Sustained attention is known as vigilance attention, a type of sustained attention explaining the person's concentration to detect infrequent and unpredictable events. Sustained attention focuses on a person's concentration on a particular task for an extended period of time whilst having to remain alert and cautious (Mackworth, 1950). An example of sustained attention is the radar watchmen on a ship. They have to remain alert all through their watch. Selective attention (also known as focused attention) is divided into two types: (1) focused auditory attention and (2) focused visual attention. Selective attention focuses attention on one source when there are plenty distractions occurred around that person. For example, in sound-only games, the game player has to focus on the sound of the spoken instructions to complete a game whilst preventing other sounds (distractions) from stopping them from completing the game. Some existing theories of selective attention include Broadbent's filter theory (1958), Triesman's attenuation theory (1964) and Deutsch and Deutsch's response selection theory (1963). Yost et al. (1996) reported that some people have the ability to perceive information from multiple sound sources at a time. It is an extent where they will be able to concentrate on different tasks at a time. Such a scenario is known as divided attention (Shinn-Cunningham et al., 2004).

2.6.2 Human Attention in Sound-Only Computer Games

According to Neisser (1967), selective "attention is serial: only one object can be attended to at any moment" (p. 301). If so, multiple sound-only presentations may cause cognitive stress.

Human attention influences the perception of sound cues that convey essential information in sound-only games. Sound also provides immediate feedback to the user (Friberg and Gardenfors, 2004). According to Shiffrin (1973) and Allport (1980), perceiving cues either from one sensory channel or from any sensory channel will engage the same attentional processes. In other words, perceiving information visually will engage the same type of attentional process as perceiving information acoustically. So, this concept could be applied directly to both visual and sound-only games. Surprisingly, it could be difficult to perceive many essential auditory messages from a mixture of sound sources. Commonly, the difficulty of perceiving more than one sound cue will result in cognitive stress (overload). Yet, the ability to extract the most important information from multiple sound sources will require an in-depth understanding of selective attention (Peissig et al., 1997; Drullman et al., 2000; Hawley et al., 2000; Shinn-Cunningham et al., 2001, 2002; Brungart et al., 2002; Devore et al., 2003).

In sound-only games, the player will sometimes be distracted by several types of sound from different sources. In fact, their objective is to listen carefully and diagnose specific sounds in order to achieve higher game scores. For instance, the implementation of several sound distractions (noise) in the sound-only game may increase the complexity of the game intrinsically, providing a better challenge to the player. Even if the game player could only perceive one auditory message at a time, the message should only be presented to their left or right ear. As long as the player can win the game, then perceiving necessary or unattended messages (overload) is not seen as important by them. The unattended messages will then be seen as an enjoyable feature of the game. This has been explored by Cherry in his "dichotic listening task" (1953). A person can only perceive one attended message properly according to Broadbent (1958) and report verbally what they have perceived without the possibility of explaining the actual meaning of the message listened (Hampson et al., 1996). Other messages (unattended messages) will be stored in the sensory buffer, and will be attended to later (Komatsu, 1994). According to Broadbent (1958), the sensory buffer is a mechanism that is used to store unattended messages for a short period of time before they are filtered. Attentional requirements are an important game feature that all game developers should understand as a game knowledge for them.

However, some suggestions have been proposed to the effect that the sensory buffer will not filter out attention-getting words such as the subject's name, significant words such as "fire" or related to sexual themes (Neilsen et al., 1981). This is another important attention feature for game designers to understand when designing a good quality sound-only game. In contrast to Broadbent's work, Treisman (1960) introduced the concept of an attenuator filter in which such words would be attenuated and not totally filtered out. The attenuator buffer would store the unattended messages attenuated to a greater or lesser extent. Deutsch and Deutsch (1963) proposed a different mechanism, namely a late selection filter that acts at the response selection stage. However, if the content of two messages attended to both ears are similar in meaning, then the attention to that particular message will be delayed (Lewis, 1970; Bryden, 1972; Treisman et al., 1974) or reduced (Moray et al., 1976) . In sound-only games, a minor delay could change the overall game score. More particularly, Treisman et al. (1967, 1969) further suggests that a person would able to attend one message effectively, that person could also monitor two messages in both ears simultaneously as long as they only attend to one particular message in one ear at a time. This is "due to no confliction or capacity limitation" (Allport, 1980, p. 132) and would be beneficial by decreasing game players' stress levels when playing games. It is important that game designers remember that a person can only concentrate on few messages at a time if these messages appear simultaneously (James, 1890) due to the limitations of cognitive capacity (Normal et al., 1975). This has been supported by a considerable volume of research (Broadbent, 1952, 1956; Webster et al., 1953, 1954, 1955; Poulton, 1953, 1956).

The challenges of a game often reflect both the complications and enjoyable contents of that game. This means that the enjoyability of a game will sometimes depend on the player's performance and not always on the game's performance parameters (Klimmt and Blake et al., 2009). A skillful game player may find a simple game very interesting. However, novice game players may not. When cognitive demand exceeds their cognitive capacity, cognitive overload will be produced. So, only game players with strong mental capacities (cognitive capacity) could continue playing the game in such overloading conditions. If so, successful game playing reflects the relationships between the player's aims, cognitive capacity and arousal level (Kahneman, 1973). The limitation of attention may be the main source of gaming problems, explaining how cognitive performance could be impaired when conducting a task. According to Allport (1980), attention represents the conscious awareness of cognition. Lack of attention means an inability to concentrate well when participating in a task. At the very least, attention plays an important role in computer games. If the game player could not commit his attention to the computer game, then game performance will be impaired.

2.6.3 The Engagement of Cognitive Overload in User and Game Performances

There are various debates about the effects of cognitive overload on the human performance. Some researcher believe that cognitive overload will reduce the efficacy of learning (Hinds, 1999; Clarke and Duimering, 2006) whilst some claimed that cognitive overload is not always a bad feature in the context of computer games (Ang and Panayiotis et al, 2006). Perhaps, the concept of cognitive overload is important and could contribute additional stimulation to computer games, in contrast to playing games without additional stimulations (stress) at low motivational levels. The lower the level of motivation in computer games, the more boring the game is judged to be and the lower the interest level and engagement in the game play (Martens, Diener and Malo, 2008). Overall, computer games are potent mood management applications that could positively enhance the game player's emotions, even if the player is addicted to it (Grodal, 2000).

Gaillard (2007) reported that the efficacy of human performance depends on the activation or arousal level of the person. If the arousal level is too low, it can be seen in sleep deprivation or fatigue effects. High levels of arousal level accompany anxiety or stress. Computer games involve both high and low levels of arousal. The low level arousal will be found when the content of the game is too simplistic. If the arousal level is high, this usually refers to a particular game with significant challenges. Therefore, cognitive overload or under load will often impair cognitive performance in game playing. In-game noise effects (Broadbent, 1971) will strongly influence the performance of sound-only computer games. Noise could significantly reduce working performance or improve it, depending on the original arousal level of the individual (Finkelman et al., 1979; Hockey, 1979; von Wright et al., 1980; Gomes et al., 1999). However, these effects could be reduced if the task is well practiced (Schoenberger et al., 1965; Newell and Rosenbloom, 1981; Kirsh, 2000). Other putative stressors (external) which causes the changes in cognitive performance include time constraints (Burrows, 2002), fatigue (Kleitman, 1963; Davis and Parasuraman et al., 1982; Eysenck, 1985; Gevins et al., 1999) and alcohol intoxication (Gevins et al., 1999). Wickens et al (1991) identified the combination of noise and time pressure will greatly impair the working (Broadbent, 1958; Neisser, 1967). Therefore, calibrating the game design to optimize stress to an appropriate level is necessary.

Different factors such as self-knowledge, motivation and emotion (Matthews and Zeidner, 2004) can trigger problems with cognitive skills. These factors are important components of cognitive performance, even in real-world contexts. Sound is an important element in games that will trigger different qualities of emotion (Kaufmann-Hayoz and Battig, 2001). This is why too much noise (intensity) in computer games produces sound pollution and adrenalin rushes (Botting, 2008). Obviously, sound pollution produce feelings of annoyance (Brewster, 2008) and overly intense noise will produce cognitive overload or stress, which can sometimes distract the game player's attention. On the other hand, emotion motivates human behavior (MacIntyre. 2002). A small change in emotion will positively or negatively impact the player's game experience. Accordingly, both motivation and concentration are relevant since motivation increases mental effort of enabling a person to concentrate on a particular task. Other factors that could motivate a game player to concentrate and learn include the reward system, levels of interest, a stimulating environment and positive feedback (Naatenen, 1973). Naatenen (1973) further discuss that rewarding system is significantly important for both the computer game designer and player since human will usually not work hard when reward fails to appear. Thus, failing to provide rewards will result in designing a lower-grade game that is unattractive. Computer game players will usually not concentrate and show lower motivation in a game if they were unable to achieve rewards from the game. They might even consider quitting the game if the game if not motivating (Sears and Jacko, 2008). Naatenen (1973) further suggests that stress will negatively deteriorate cognitive performance and attention. If so, high or low emotions could impair user performance, not only in the computer games context, but also in relevant tasks (Gaillard, 2001).

Of direct relevance to the context of computer games, increasing practice can mitigate dual-task and cognitive overload effects (Tulving, 1981). Thus the combination of practice level and secondary task addition, as explored here, might be expected to introduce valuable interactions in a well-designed game. Yet, the principle idea here is that limitations of attention are produced by various stress effects. Alternatively, human performance also depends on the amount of practice of the user. Based on the long and traditional understanding of performance, the accuracy and performance rate of a particular task increases over a number of trials (Yerkes and Dodson, 1908; Chiarenza and Stagi, 2000). Rosenbloom et al. (1987) reported that "performance improves with practice" (p. 221). If the user is familiar with a task, the stimulation of cognitive overload will subsequently be reduced. Instead, task performance continues to increase. On the other hand, in sound-only games, game player may feel vulnerable when observing sound cues simultaneously. This circumstance leads to a decrease in attention. If attention decreases due to cognitive overload, then cognitive performance will also decrease. Therefore, significant amount of game playing will increase the user's interest, performance and learning experiences in certain circumstances only. Clearly, this is an important motivational aspect that will contribute to the understanding of game performance.

A few other obvious positive factors influence cognitive performance in the context of computer games, including the difficulty level (Navon et al., 1980) and user concentration (Naatenen, 1973). Interruptions, boring drawbacks, and fatigue effects (i.e. time-of-task, time-since-awake, boredom etc.) inhibit concentration on a task. Naatenen (1973) suggests that these effects usually combine to impair cognitive performance. In the context of computer games, when players carried out two or more simultaneous tasks at a time, performance will decrease (Norman, 1968; Welford, 1968; Broadbent, 1971; Kahneman, 1973). Dividing attention (or dual-task performance; Colman, 2001) such as performing two different tasks at a time will also decrease task performance. This was shown by Shiffrin et al. (1981). Generally, performance decreases when the user cannot concentrate well when executing a task (Galat, 2010). The user could not concentrate on many tasks due to the limitations of capacity in the working memory (Norman et al., 1975; Kalyuga, 1997).

2.7 Limitations of the Literature

A general review of the sound-only computer games has been conducted. The previous sections of this chapter have explained the importance of the psychology-based design of sound-only games, applying different psychology theories and important heuristics. The understanding of what makes enjoyable sound-only games is important. Such a game is highly important for people with visual difficulties or those who simply prefer the challenge of the game. The importance of sound visualization in such games could help to extend various cognitive skills for people with visual disabilities, such as memory and motor skills that are important for their daily lives. So, the enjoyability aspects of sound-only games are a top priority for designers, so the users can learn play well and to enjoy the game playing experience.

The universal power laws of practice are supposed to be robust and ubiquitous (Newell and Rosenbloom, 1981) explaining that performance should improve with practice. The power law of practice was also suggested as an artifact of aggregation and the exponential law of practice has been offered as an alternative (Anderson and Tweney, 1997; Myung, Kim and Pitt, 1998; Hung and Adams, 2010). At the moment, it seems that sometimes that power functions are found and that sometimes exponential functions occur. It is not yet clear why this is so. Clearly, this is an important issue that should be explored in the experiments in this research.

Chapter 3

Human Understanding Theory for Novel Games with Simplex

3.1 Introduction

A relevant starting point is to explain the differences between a theory and a model. Indeed, they are quite different (Meleis, 2007). In fact, a theory is "a set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or is widely accepted and can be used to make predictions about natural phenomena" (American Heritage Dictionary, 2000) whilst a model is "a depiction or simulation of a theory that assumes the theory to be true and captures aspects of the theory that are relevant to the task at hand" (Adams, in press).

Theories and models are not the same. By definition, a theory is testable by reference to some experimental facts (L'abate and Bryson, 1994). A testable theory is one that offers feasible test of the theory (Boland, 1989). A theory also refers to an attempted explanation of a set of phenomena. L'abate and Bryson (1994) suggest that a theory is "an attempt at interpretation and explanation of reality as one sees it" (p.5). In psychology, a theory represents an understanding of human cognitive processes. On the other hand, a model is more restricted and will not be able to produce a full set of explanations since its only purpose is to "test part of a theory through description" (L'abate and Bryson, 1994, p.5). In other words, a model has to depict a theory, often in part (Meleis, 2007). Therefore, a model is an instantiation of a theory applied to a specific case, such as a set of users, a single user or a cognitive task.

3.2 Human Cognitive Architectures

3.2.1 Introduction

One popular type of psychology theory of cognition, namely the human cognitive architecture (or cognitive architecture) provides a powerful method to guide system designers to design effective interactive stimulations, particularly computer games. A cognitive architecture is useful as long as the theory remained feasible and valid (Sutcliffe, 2000), and unnecessary complexities of the theory are well hidden (Adams, 2005). More importantly, a cognitive architecture should function properly in complex environments (Pollock, 2010). West, Lebiere and Bothell (2006) suggest testing computer games with a cognitive architecture since computer games require complex cognitive strategies that a cognitive architecture can capture and depict. Human cognitive architectures have been used to evaluate human performance. For such, it has been used as a basis for building a better understanding of relevant cognitive processes (complex thinking) in the context of performance. For example, Robert and Stenberg (1993) has successfully used the diagnostic measure of additively versus interaction in the context of reaction time to identify different cognitive processes.

Overall, the cognitive architecture is a type of cognitive science theory, representing a set of mechanisms and aimed at cognitive processes (Ritter and Reifers, 2006). According to Gray, Young and Kirschenbaum (1997) and Ritter and Young (2001) a cognitive architecture depicts "a scientific hypothesis about those aspects of human cognitive that are relatively constant over time and relatively independent of task". Earlier, cognitive scientists computed a cognitive architecture to help them solve cognitive issues (Newell and Simon, 1963). Today, many HCI designers use a cognitive architecture as a guide for them in the design of user interfaces (Bryne, 2003) and in effective multimedia learning (Mayer and Moreno, 1998). In other words, a potential and well-designed cognitive architecture could generate an overlay of different techniques to explain complex cognitive processes, involving stress, attention, performance, problem solving and decision making.

3.2.1.1 Different Types of Human Cognitive Architectures

There are at least two types of human cognitive architecture; complex and simplistic theories (Adams, 2007). Here are some examples of complex theories: ACT-R (Adaptive Character of Thought; Anderson, 1983, 1990) and SOAR (Symbolic Operator Architecture; Laird, Newell, and Rosenbloom, 1987; Newell, 1990). Complex theories are intentionally designed by researchers for other researchers. They were designed with distinct aims, aiming at learning and intelligent behaviour (Hudlicka and Zacharias, 2005) and may not be accessible to information and communication technology (ICT) design practitioners since they focus on more complex systems design such as pilot training stimulation for aircraft and helicopter modeling. Simplistic theories such as Atkinson and Shiffrin's memory theory (1968), MHP (Card, Moran, and Newell, 1983), Maltese cross (Broadbent, 1984) and Simplex (Adams and Langdon, 2003) are designed to be useful and accessible for both researchers and practitioners.

The proposed theory, namely the HUNGS theory (explained later in this chapter) is developed in the present research and is a simplistic theory. The aim is that this simplistic theory could retain sufficient complexity to capture the relevant and important features of effective sound-only games.

Simplistic theory is further divided into two categories, that are the early and current theories. Earlier simplistic theories include Atkinson and Shiffrin's memory theory (1968) and the Model Human Processor (MHP, Card, Moran and Newell, 1983). They are potentially important theories. However, these theories have now been overtaken by more recent research findings. For instance, the MHP focuses on user-centered design to evaluate interactive systems. Unfortunately, the MHP theory could not capture more complex findings of cognitive processes, such as the working memory. So, this theory is somehow an incomplete theory (Preece et al., 2002), or intentionally never a complete theory (Adams, 2007) for interactive systems design. Therefore, researchers continue to update and build newer theories from the existing. For example, theory such as Simplex Two (Adams, 2007) was build upon the Maltese cross (Broadbent, 1984). The Simplex Two theory could work to guide good practice and support applied research. Other prominent simplistic theories include the Upper and Lower mechanisms, a theory of stress and arousal (Broadbent, 1971).

3.3 Simplistic Theories

3.3.1 Some History of Simplistic Theories

"Simplistic theory is one which can both act as a framework to contain a rich level of theoretical detail, yet also be capable of being packed up into a simple, overall guide for good practice" (Adams and Langdon, 2003).

It is not easy to design a truly accessible and enjoyable sound-only computer games because this type of computer game require complex processes involving many processing skills. The general term of sound-only computer game refers to games designed only for specific user groups. On the other hand, dealing with disabled people (Shiose and Toda et al., 2007), particularly visually impaired people (Choruma, 2007) and blind people (Tsivian, Taylor and Bodger, 1994) would require more proper and careful consideration of human perception. Careful consideration of the design process is also important as many people have very different needs (Keates and Clarkson, 2003). Clearly, accessibility is an important consideration for such groups of users (Eriksson, and Gardenfors, 2004; Friberg and Gardenfors, 2004; Targett and Fernstrom, 2003). There is considerable research focusing in computer games design (Pardew et al., 2004). One purpose is to produce accessibility (IGDA, 2005) in a more enriched form of computer game environment for their players. Overall, to date, there is too little specific research studying sound-based games and its specific user groups in any detailed way (Ekman and Lahti, 2005), such as understanding the user's cognitive process and the optimal designs of such games.

To date, sound-only games have received little attention from designers due, in part, to the unavoidable complexity of such game plays. The definition of sound-only game refers to games that require auditory perception only, rather than other modalities. Originally, sound-only games have discouraged sighted players from participating even though sound is usually a prominent medium of interaction (Drewes and Mynatt et al., 2000; McCrindle and Symons, 2000). If only the sound-game designers could first understand users' needs, starting from their understanding of cognitive processes, then achieving best user experience could be possible. In fact, evaluating user experiences in games provides designers with substantial supporting research, since the earliest paper written by Malone (1981). It is still an important issue related to computer games, particularly in new games development (McAllister and White, 2010).

Generally, sighted people prefer visual computer games. Sound-only games require greater auditory perceptual skills and unlike other modalities may produce more stress for most game players. So, any game players who are not familiar or used to sound elements will not like playing this type of game. Another common reason is that sound-only games are usually harder to calibrate since designing accessible games require critical understand of the user and cognitive process (Pardew et al., 2004; Brandon, 2007). This is the element which makes sound-only games hard to play! In other words, the design of satisfactory sound-only games could be a serious issue since a game player's satisfaction is very sensitive to the success of the game design itself

(Malone, 1982; Dyck and Pinelle, 2003). To produce a reliably accessible game, the game developer must first capture user needs and preferences for an enjoyable game. However, it is not an easy task to understand user needs. For example, simplistic games will usually attract less attention from experienced users since these users (expert users) would not see the game as sufficiently challenging (Coleman, Macaulay and Newell, 2006). Naturally, learning happens when one is deeply engaged in difficult and challenging tasks (Taylor, 2006). If only challenging tasks motivates the player to learn, then game players will never enjoy from simplistic games. So, the present notion is that a feasible cognitive architecture is necessary to provide a better capture of the complex cognitive processes in order to create suitably stimulating computer games.

3.3.1.1 The Simplistic Theory Background

The concept of the simplistic theory was first introduced by Card et al. (1983) when they build the Model Human Processor (or MHP). Originally, the MHP was introduced to evaluate interactive systems based on user-centered design methods. It provides simple capture of human cognitive processes. However, as time passes, many researchers tried to explore and build their own cognitive architectures to evaluate different system design. At this point, they claimed that the MHP was never a complete theory (Preece et al., 2002). Instead, it is best considered as a potential guide to evaluate system design for user interfaces (Atakan, 2006). The MHP consists of five modules; perception, cognitive processing, short-term memory, long-term memory and response making). These are the five components used to capture complex understanding of cognitive processes such as user processes and knowledge-based processes.

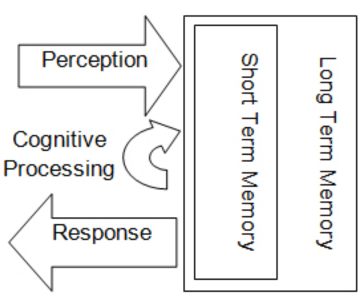


figure 3.1 Model Human Processor (MHP, Card et al., 1983)

Broadbent (1984) designed the Maltese cross theory. His theory shares the simplicity of the MHP, though the Maltese cross focuses the human memory. Similar to the concept of working memory proposed by Baddeley (1986), the Maltese cross claimed that the short-term memory module is a property of the working memory and is not an isolated memory store (Adams, 2005). Thus some people who suffer from head injuries can have an efficient long-term memory but be impaired in their short-term memory (Shallice and Warrington, 1970). The Maltese cross theory provides only five components; sensory store, abstract working memory, long-term associative store and the motor output and a processing system. This theory does highlight two advantages over the MPH theory. First, the Maltese cross has a two-way flow between the input and output. Second, it has a well delimited executive function for processing purposes.

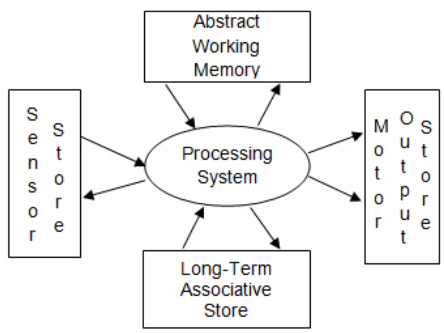


figure 3.2 The Maltese Cross Model, Broadbent, 1984)

Broadbent used the following scenario to depict his theory; a clerk working in the office. There is one basket each at his left and right. The left basket receive incoming letters from other staff in that office. The letter depicts incoming sensory cues. The right basket is the output, portraying the motor output. There is a working desk located in front of the clerk for him to work out his assignments. The desk illustrates the working memory. If the clerk need some help with his assignment, he will refer to some documents or files stored in the cupboard placed behind him. The cupboard refers to a person's long-term memory store. Finally, when he completes his assignments, he will leave everything done in the right basket (output).

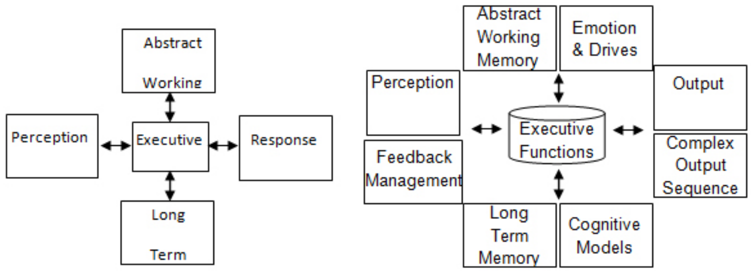


figure 3.3 Simplex One (Adams and Langdon, 2003) and Simplex Two (Adams, 2007)

Simplex One is a simplistic theory that builds upon the Maltese cross (figure 4.2). Simplex Two (figure 3.3) is an enhanced version of Simplex One, providing four additional modules. Simplex Two aims to guide system designers to develop interactive systems. Indeed, it may be suggested that it is important to provide a systematic and conceptual framework to guide system designers to solve their design problems (Adams et al., 2002). Although the Simplex theories are similar to the Maltese cross, they have different aims. The Simplex theories provide a simple and conceptual approach to design evaluation, designed to provide best capture of HCI aspects. This approach contrasts with the Maltese cross that is principally a memory theory used to provide a better understanding of memory.

Adams (2007) reported that the five modules in Simplex One are insufficient to deal with the results of two large validation studies and of feedback from system designers. So, he further upgraded his theory Simplex two contains nine modules. Five modules from Simplex One and four are new modules. They are; feedback management, emotions and drive, cognitive models and complex output sequences. The four modules were developed based on the basis of two validation studies (Adams, 2007), the existing literature and designer feedback. Simplex Two is used to evaluate user needs in system design. It also highlights accessibility and usability aspects of a system. Unlike the Maltese cross, all modules in Simplex two have the processing capacity.

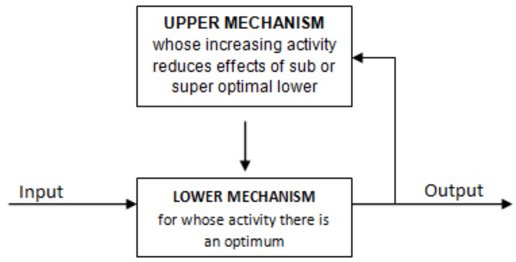


figure 3.4 Upper-Lower Mechanisms (Broadbent, 1971)

The dual-mechanism theory of Broadbent (1971) is a stress and arousal theory. On the other hand, the upper mechanism has the ability to monitor the overall progress of performance. The lower mechanism could be protected from the effects of stressors by the upper, compensatory (or gating) mechanism that protects performance until or unless the upper became inefficient due to fatigue or cognitive overload (Wilkinson, 1962) or due to stressors such as alcohol intoxication. Broadbent used the two mechanisms to explain the effects of environmental stressors such as sleep deprivation and noise. According to him, sleep deprivation influences the speed of task whilst noise affects the accuracy of task. However, when the two effects applied together they can cancel each other out. In addition, the effects of either stressor tend to be apparent only at the end of a working session, when the Upper system becomes inefficient and cannot protect the Lower system from the impact of either stressor.

3.4 Overview of the HUNGS Theory

3.4.1 Introduction

The concept of accessibility should be applied to all information technologies so these systems could be made accessible for a wide range of intended users with different cognitive abilities (Adams, 2007). The understanding of accessible should extend to computer games, so users with special needs such as blind people could have some opportunity to gain access to such interactive multimedia applications. However, before designing accessible computer games, the most important phase is the understanding of the accessibility concept. According to IGDA (2004), accessibility refers to "the ability to play a computer game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities - such as blindness, deafness, or mobility limitations." (p. 5). Yet, it is never an easy task to design such games to match the requirements of disabled users to those interactivity features provided by computer games (Sepchat and Clair et al., 2008). To do so, game designers have to understand the psychological variations of extrinsic features of a potential computer game system, in order to generate some insights of users psychological, to cast light on their requirements. Shneiderman (2003) and Shneiderman et al. (2002, 2005) suggest that attempts to capture necessary system design and development factors will work best when based on generative theories that generate design options and act as a potential guide for designers and practitioners. Adams (2007) further explained that generative theories could be effectively used to predict and evaluate the usability and accessibility of a system.

The acceptability of a computer game will relate to games enjoyability. This is always a crucial aspect in the context of the design of new computer games. Pashler (1998) and Rai, Beck and Heffernan (2010) suggest that user motivation and level of experience in computer games are linked to cognitive overload. So, another important aspect of games acceptability relates to overload features. However, most current stress theories such as Wickens' theory of stress (1998) have not been applied to interactive games design, due to, in part, the complexity of the concept of stress (Ritter and Reifers, 2006). Indeed, computer games require an appreciation of complex cognitive processes (Klasen and Zvyaginstev et al., 2008). Ritter et al. (2007) suggest that the combination of cognitive architectures and other relevant theories such as human stress theories can provide a better capture of human performance. Hudclicka and Zacharias (2005) claimed that a successful cognitive architecture requires specific sets of performance requirements to generate explanations for the effects of individual differences and stimulating stress states (i.e. decision making).

Two existing theories were chosen as a basis for further work. The two theories are the two-level mechanisms (Broadbent, 1971) and Simplex two (Adams, 2007). Neither of the two existing theories is intended to be complete nor were they designed for application for games accessibility. Broadbent's two mechanisms theory is a stress and arousal theory, aimed at capturing cognitive performances and different effects of stressors and stress. Simplex Two is a cognitive science theory, focusing at the accessibility and usability of interactive and assistive technologies. The HUNGS theory builds upon them both to create a more complete theory, taking the best of both theories and applying them directly to sound-only computer games design (and accessible computer games in general) for use by visually disabled users. Such a theory will be used to develop and evaluate the acceptability and usability of sound-only games. Part of this theory will generate a set of usability computer game questions (questionnaire) for the participants. Their feedbacks are helpful to generate sets of heuristics; for games design and game play. The heuristic is important, contributing in two aspects. First, game designers could use the heuristic to design accessible and enjoyable (stress optimized) sound-only computer games for special user groups. Second, the production of such game could highlight some aspects of a game to motivate game players to learn from playing a game.

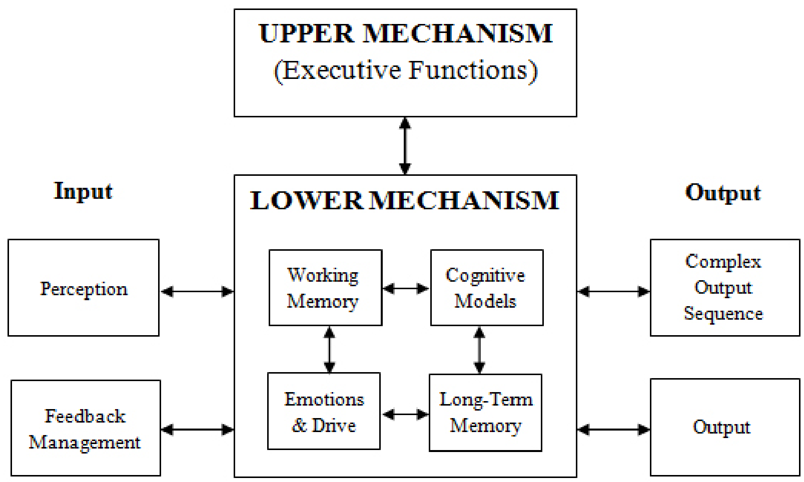


figure 3.5 Human Understanding theory for Novel Games with Simplex (HUNGS)

Loftus and Schooler (1978) argued that the previous simplistic theories have difficulties in certain aspects, such as transferring of information between stores (Cowan, 1995). They do not contain components that allow for flexibility in control processes similar to Atkinson and Shiffrin's Memory theory (1968) and a memory motor similar to Sperling's Short-Term Memory (1967). As a result, these theories cannot capture more complex cognitive process.

The HUNGS theory (figure 4.6) attempts to overcome some restrictions found in previous simplistic theories, such as the MHP and Maltese cross. The HUNGS theory also attacks these issues with potential solutions; it contains a memory motor (integrated with the lower mechanism) as a distinct module. The HUNGS theory has flexible control processes, where the skills depend on the production of subroutines that specify the required operations and their order. Information can be passed from one module to another flexibly in the lower mechanism, and send to the upper mechanism for further stress monitoring. This could help evaluating complex cognitive process such as the experience of stress. It is suggested that information could bypass the upper mechanism with practice, thus explaining the familiarity of a task when well-practiced.

Based on the findings of research (Broadbent, 1984; Baddeley, 1986, 1990; Adams, 2007), the HUNGS theory uses the concept of working memory (WM) theory rather than the short-term memory (STM). The reason for not having STM module as a separate item in the lower mechanism does not mean that STM is not an important aspect in human cognition. The STM is not seen as a separate function in the HUNGS theory, instead it is seen as a property of working memory. This is illustrated by Shallice and Warrington (1970) who found that when people with head injuries have strong long-term memory (LTM) often performed badly in STM. This would not be expected to happen if information going into the LTM must go through STM first. Therefore, the best explanation in this context is to state that information going through the working memory for processing and the working memory will allocate the information to the appropriate module (STM or LTM). The concept of working memory was further explained by Baddeley (1986).

Building on the Two Mechanisms theory, the upper mechanism in the HUNGS theory is equated to the central executive. The upper mechanism monitors the overall progress of performance (including the lower mechanism) to maintain constant user performance. The lower mechanism will observe different executions of game activities related to the establishment of game player's decision processes. However, similar to the explanation provided by Broadbent (1971), if the upper mechanism becomes inefficient, the overall game performance will decline. The effects of other stressors states (e.g. sleep deprivation, noise and fatigue) are dealt with by this theory. Page and Page (2003) suggest that major stress effects such as noise could impair user's perception and performance in complex tasks. Too much noise will sometimes distract the game player, minimally reducing game performance. Broadbent (1985), Treisman (1964) and Deutsch and Deutsch (1963) reported that a person can rarely attend to all incoming auditory messages at a time. This is indeed a serious consideration that a sound-only games designer should bear in mind. The executive function is a very important concept that is implicated in cognitive disabilities, though surprisingly some more theories such as ACT-R do not incorporate an explicit executive function (Anderson and Lebiere, 1998).

The HUNGS theory aims at capturing and understanding the computer game player's cognitive processes, and applies key concepts to develop a set of questions for participants who participate in the experiments sessions (this will further be explained in chapter five). Such a theory aims to provide sound-only game designers and practitioners with a simple roadmap to use when designing and evaluating their games. The heuristic questions should be able to predict the game performance, acting as a basis of questionnaires that will be applied in system evaluation based on the novel games (namely Totally Lost, Totally Lost 2 and Totally Lost 3).

3.4.2 The Modules of the HUNGS Theory

3.4.2.1 Introduction

The HUNGS theory postulates nine components overall, eight components in the lower mechanism and an executive function (upper mechanism). The upper mechanism will act as the central executive to monitor users stress and level of activities related to playing sound-only games. The components in this theory were linked in a two level form to support a more dynamic and flexible way of processing. Eight components contained in the lower mechanism will hold information stored for a period of time for further processing. The eight components have a role, which is to transfer information from one module to another after recognition and processing. Typically, the transferring of auditory messages can take place back and forth from any of the modules and to be sent to the central executive for further monitoring.

Initially information processing was conceived as a one-way or serial process as presented in pipeline theory (Broadbent, 1957) and MHP (Figure 4.1), but subsequent work supported a view of human information processing as at least a two way process (Broadbent, 1984). If so, is not valid to explain complex process relevant to playing sound-only games in terms of one-way processing; that is also one of the reasons why these theories were unable to explain more complex problem solving and decision-making tasks. One example is to explain the execution of several tasks (also called dual-tasks and divided attention) at any one time. For example, when playing a game and listening to news from a radio, perceiving too many representations (perception) at a time will result in the demand to transfer information simultaneously between the sensory and the LTM modules, and will stress the person's cognition. Existing research (Becker and Killion, 1977; Broadbent, 1977; Navon, 1977) suggests that users prefer to have cyclic processing, as found in some existing cognitive architecture theories (Atkinson and Shiffrin, 1968; Broadbent, 1971, 1984; Baddeley and Hitch, 1974; Koopman and Wierdsma, 2000, pp. 309; Konar et al., 2005, pp. 21; Adams, 2007) to explain how information is circulated in cognition. The cyclic approach presents human cognition as based on the circulation of information between and within cognitive modules (Adams, 2007).

Therefore, every module contained in the HUNGS theory will have its own functions, memory capacity and processing capacity where it is capable in transferring information from one module to another (a cyclic approach). The combination of all modules in the upper and lower mechanism in the HUNGS theory can effectively used to explain complex cognitive processes when playing sound-only games.

3.4.2.2 Evidence of the HUNGS Theory

The Upper Mechanism. The upper mechanism is the central executive in this theory. It has a function to monitor the overall performance level of a user. This module is a very important component since different stress effects affecting the Lower mechanism will be compensated by the Upper mechanism. This means that the upper mechanism (executive functions) monitors the overall progress of the lower mechanism by exchanging information back and forth between the two mechanisms and to hold records of sequences of such transfer to evaluate human stress level when that person is playing sound-only games. According to Broadbent (1971), as long as stress effects such as fatigue and alcohol intoxication do not impair the upper mechanism, the person's performance will remain constant. In the HUNGS theory, time of task is an additional challenge that motivates or discourages the user to play the game. Game loading time is an additional feature promoting stress (frustration) and user performance and should not be ignored (Nah, 2000). Playing sound-only games for the first few attempts is considered as conducting task based on controlled and conscious processes where processing speed is often delayed due to limited capacity processes (Shiffrin and Schneider, 1977) that are used when dealing with complex activities. One explanation of these delays is that the auditory information is sent to the upper mechanism more frequently for monitoring and therefore, the speed of overall processing is delayed. The upper mechanism plays an extensive role in accessibility to support user performance (Stephanidis and Savidis, 2001; Johnson and Kulkarni et al., 2005) when evaluating sound-only games designs. For example, expert users may consider that a game that they have designed is at acceptable level, such that all game users should be able to play the game effectively. However, they may overlook the possibility that game users may perceive their game in a different way.

Perception. The perception module deals with information perceived by the human senses (auditory, visual, tactile, taste and olfactory). Most interactive games research emphases both visual and auditory perception. There are several approaches to visual processing. For example, Gibson's ecological approach (1979) proposes that visual perception is a relatively direct process, where the properties of objects in the visual field are directly appreciated through a process of affordance. Thus a chair can be seen to "afford" sitting down, a door affords opening etc. Properties are directly perceived. The notion of affordance has been picked up by HCI researchers, notably Donald Norman. When designing a user interfaces, the screen objects are designed to indicate their functions through a similar process of affordance, though Donald Norman has subsequently pointed out that the two types of affordance (visual field versus user interface) cannot be considered to be identical. An approach to visual perception as a much more constructive process has been developed by Richard L. Gregory (1997) in his book entitled "Eye and Brain: The Psychology of Seeing". He has provided a very clear explanation of this approach with illustrations, explaining how visual perception processes such as motion perception, glimpse, and brightness work. Similarly, in auditory perception, one most notable work, known as the selective attention theory (Broadbent, 1984) will have provided similar explanations for auditory perception. Since the current research focuses on sound-only computer games, the following section and explanation of this module will be based purely on auditory perception.

Sound perception is not a one-way process, when storing in the working memory. For example, we may recall a song or a familiar face. In fact, the sound perception process consists of many processing pathways, particularly in complex listening environments (Bregman, 1990). Therefore, auditory selective attention plays an important role to direct the user's attention to select a sound for attention in complex gaming environments. For instance, many sound cues may be presented to the user independently without causing interference among them (i.e. talking, mobile phone ringing etc). Though, the user can mask less important sounds if one more intense or important sound is presented at the same time (McAdams and Drake, 2004). In other words, the auditory perception has its own processing capacity in order to decide where information should be transferred. Thus, speech processing and music perception may often operate in parallel, since music perception requires higher variability in abilities and learning that combines with substantial musical training and inherent individual differences (Baars and Gage, 2010). So, music processing requires a different set of cognitive processing skills. This is a highly important consideration that game designers should consider when handling background music and individual in-game sound for the games they design.

Abstract working memory. Working memory (WM) is a temporary store for information used whilst working on a task (Kandel et al., 2000). The WM has the potential to selectively filter unnecessary auditory cues perceived. The WM has been used in this theory as a replacement of STM (Shallice and Warrington, 1970). STM is a property of the working memory. After perceiving the auditory cues during perception, the information will then be sent to the WM for further analysis. Broadbent (1984) explained the working memory as a store that will capture the information until the subsequent information perceived will eventually replace the previous information. The working memory is important when linking perception (sensory) and output (motor). The dual task effects found in short-term memory have encouraged ongoing research to explore the concept of working memory (Baddeley and Hitch, 1974; Baddeley, 2001). In this theory, the WM has been used as a component to evaluate the two important aspects of the interaction between sound-only games and the user; firstly, to examine if the game system produces too much demand on memory consumption by the users WM and secondly it is important to understand if game users have sufficiently good memory skills to play the game. Working memory has been seen as being of limited capacity (Broadbent, 1975; MacGregor, 1987; LeCompte, 1999). Where this putative capacity is exceeded the information may be fade away or be displaced. When this happens during game play, some game players may not be able to successfully complete the game when they have to hold seven or more sound cues in their working memory at one time. Clearly, such considerations can be applied to aspects of game design such as game menu size and complexity. Such aspects of good design could enhance the user's performance and reduce game users' memory load (Puntambekar, 2009).

Long term memory. "Everything in life is memory, save for the thin edge of the present" (Gazzaniga, 2000). Long-term memory (LTM) or permanent memory is very important in the context of computer games. It deals with long-term information captured for human cognition. LTM is a module contained in the lower mechanism of the HUNGS theory. It deals with long-term data storage within cognition. Some researchers argue that information contained in the working memory must be rehearsed. Else, the information either will fade away (Peterson et al., 1959) or be replaced by other information. Only a proportion of information processed in the working memory will be sent to the LTM upon rehearsal (Nara, 2003) since every piece of information contained in the LTM "has been learned in order to cognitively adapt to an environment" (Sweller, 2005, p.20). This memory store can hold information for many years (Weisler and Stillings, 1995; Stolovitch and Keeps, 2002). The

LTM module in this theory deals with the availability and accessibility of the users' memory capacity and skills when playing sound-only games. For example, blind users rely on sound cues to determine their performance. If so, their LTM ability is important since the sound contents perceived will be stored in the LTM and determine their enjoyability level and gaming experiences. For instance, novice gamers may possess less knowledge compared to expert gamers who play games often. This has a direct relationship to the challenge and control of the game. Blind gamers will rely heavily on their auditory LTM to play the sound-only game, since they are unable to refer to visual memory for pictures and movements. Therefore, it is necessary to have some memory support from their LTM to supply them with the necessary auditory information. On the other hand, sufficient amounts of practice (trials) could contribute to building stronger long term memory and better game performance (Gurubatham, 2005). LTM can be overwhelmed when the game players need to process substantial amounts of sound cues when playing sound-only games. This can happen when gamers are require to memorize their previous game scores in order to attain better score in their next attempts as the game becomes more challenging.

Output (i.e. responses). In the context of sound-only games, when blind users perceive sufficient information, the information perceived will be transferred by means of two mechanisms in the HUNGS theory (various stages in cognition). This will determine if the player can control the game properly. If the game controller (i.e. keyboard, mouse, and joystick) is not easy to use or if they are not familiar with the controller, their performance will be impaired. The information must be processed and responses finally executed in the output module including psychomotor and vocal responses.

Adams (2007) reviewed the existing literature and found that four additional factors (in addition the four components covered by Simplex one, see Figure 3.3; perception, abstract working memory, long-term memory and output response) are important for interactive systems design. To ensure that game designers would be able to produce a more enjoyable inclusive system, these four additional modules are included in the lower mechanism of the HUNGS theory. The four additional factors are feedback management, cognitive models, emotion / drives and complex output sequences. These are important modules that could contribute to ensure that potential sound-only computer games are accessible and enjoyable. Therefore, nine modules are contained in the HUNGS theory. The four additional modules are important to explain some accessibility features of the games, supporting a critical evaluation of relevant cognitive and HCI issues related to such games. This was also validated by discussions with system designers (Adams, 2007) established to solve design processes related to HCI.

Feedback Management. Unlike the perception module, the feedback management deals with the feedback from the environment. This module is important for game players and determines the basics of learning. The feedback management will encourage the players to learn, providing sufficient feedback to guide the player when playing the game. For example, in a racing game, the amount of visual feedback provided will encourage sighted players to learn quicker than blind players. The reason is that sighted players will able to identify the environment in the game whilst handling the car and not crashing it. The question here is, how can we provide the same level of feedback for both players, encouraging them to learn more effectively? The feedback management is also important to determine the accessibility of the game. Sufficient feedback will allow the game players to participate in the game yet adjusting the complexity level. However, too much feedback might ruin the game play. If the player always looses the game when he reached to the forth checkpoint no matter how many trials, that player will subsequently feel too demotivated to continue playing the game. So, an optimal feedback level is important to enhance the overall game experience (Salen and Zimmerman, 2004).

Cognitive Models. The mental model is a coined term of cognitive models research (Laszlo and Polya, 2002), and is a highly important module for sound-only game designers and other practitioners, since blind gamers have limitation in visual perception and outcome in selective perception since it helps to predict massive demands on decision-making that may overload the processing and cognitive capacity (Karasek, 1998). The mental model is a prediction model, providing a consistent structure to predict user and game requirements (behaviour, function, capability and limitation) by treating the user a complex system and his or her functions (requirements) with a mental representation or model. Here, the cognitive model captures the user's knowledge of the game system and is important when producing a good storyline. It is never an easy task to produce interesting storylines for most games (McGuire, 2009). Furthermore, a game with a pleasing and appealing storyline increases performance (Boyle and Connolly, 2008). The better the game designers understand the mental models of users for games, the better they can identify their needs and requirements for an accessible and enjoyable game they can develop. Cognitive model effect the emotions, and that relates to the response in challenges of a particular task (Karasek, 1998). Fullerton et al. (2004) reported that modeling the stimulation and the enjoyability of the game based on the critical understanding of user's mental model is also necessary. It will result in better strategies of designing an enjoyable sound-only game since a potential mental model will act as a guide to the system designer (Crow et al., 2000) and to the user interface designer (Rushby, 2001). On the other hand, this is an important aspect aiming at the effectiveness of a particular game design. Bogost (2006) suggests that an effective mental model will be able to increase user's capabilities (through better accessibility and enjoyability) when using a particular system. Therefore, a potential cognitive model is very important to guide blind gamers to play the game though they are only novice gamers with such games.

Emotion and Drives. The relationship between emotion and cognitive overload has led to an important understanding of enjoyability and game performance. According to Gardner (1985), emotion is a key "which may be important for cognitive functioning" (p.6). Christianson (1992) suggests that emotion will influence different attentional processes. Creating interesting ethical game play issues such as those that concern user's privacy should be regarded as a major aspect of the role of emotion in game playing (Sicart, 2009). Imagine if the player does not want their game scores to be published, so their game scores could not be seen by other game players. This aspect is important since the emotional consequences could negatively impact game performance. Smith and Lazarus (1993) reported that different emotional states would occur, depending on the person. Emotion may positively influence user's game performance when the person is happy. A negative emotion will occur when a person could not achieve their goal (Eysenck and Keane, 1996). Conversely, having a negative emotion will decrease user's performance (Locke and Latham, 1990). Hanin (2000) and Krane (2006) found that both performance and emotion are correlated since "performance will affect emotions and emotions will influence performance" (p. 658). Therefore, changes in emotion will affect human memory and as a result, increase users stress levels. Participants' self-reports in this research have highlighted the importance of emotion in sound-only games. When game users are feeling frustrated, they are not be able to concentrate well on the game play. Stevens (2006) reported that the changes of mood (and emotion) would also influence a person's performance. This explains why changes of mood will cause their game performance to degrade. Adams (2007) suggests that emotion is an important feature for universal access and inclusive design and would particularly be difficult to achieve in user-centered design.

Complex output sequence. When playing most interactive games, a player must learn to adapt and develop complex output sequences or skills. Once learned, these response sequences can be "fired off" without further reference to input or feedback. For example, suppose that a game requires a player to "refuel' his or her vehicle.

Once that decision is made, the refuel sequence is carried out. Additional examples would be in a shooting game when a player learns how to hide in order to evade his enemy. Once learned, he will automatically hide from his enemy when he heard some footsteps approaching him. Thus, complex output sequences are involved in the planning stage which involves critical decision-making to enhance blind or visually impaired players' capability to produce these complex responses in sequence, without needing visual input. Skilled and complex response sequences allow players to develop their cognitive skills to achieve a particular solution and attain their goal (usually to complete the game within the time frame to obtain higher game score). This approach would acquire blind users to systematically produce an effective strategy for the development of complex response. Such complex responses may lead to greater competency in effective learning and will provide them with greater enjoyment.

3.4.2.3 The Relationship of User Sensitive Inclusive Design and the HUNGS Theory

The concept of the accessible design of a system has been developed further with the growth of Inclusive design. According to Cifter and Dong (2010), inclusive design refers to accessible systems designed for everyone including people with cognitive disabilities. The design pyramid proposed by Benktzon (1993; see appendix) illustrated three layers of disabilities (e.g. severely impaired, moderately impaired and able-bodied). Benktzon reported that the design of a system is usable for all users in the same disabled group. For instance, blind people are classified in the group of moderately and severely impaired (Bruno and Amp, 1998). So, the designs of sound-based computer games are aimed to be accessible for people in the same disability group.

The concept of inclusive design has been explored, and has gained popularity among system designers engineer practitioners. They hope to include a new understanding of their users, gaining valuable insights into their user's needs and to solve most accessibility and usability design problems. To do so, a number of concepts were employed to interact between the system and users, such as the user centered design (Schneiderman, 1992; Newell, 1973; Preece, 1994; Helander, Landauer and Prabhu, 1997). However, the user centered design has often found it difficult to include people with cognitive disabilities as part of their design process (Alm, 1994). Indeed, this is a serious challenge for most designers.

Principles	Description
Equitable	The product is useful and marketable for people with visual impairment
Flexible	It can accommodate blind individual needs and preferences
Intuitive	The product is easy to use
Effective	It works in most situation and for blind users
Tolerant	The product can cope with user-errors
Efficient	It does not stress or tire the blind user
Appropriate	It is ergonomically designed to be acceptable for blind users

table 3.1 Modified Principles of the USID (for Visual Disabled Users)

Newell and Gregor (2000) suggest including a new design paradigm in the user centered design concept. Here, they have introduced the user sensitive inclusive design approach (USID). The USID is an enhanced version of the user centered design, that focuses specifically on the efficacy of inclusive design systems for users with extreme needs (Gregor and Newell, 2001). There has been some discussion concerning the differences between the two concepts. Norman (1986) suggests that the "user-centred design emphasizes that purpose of the system is to serve the user, not to use a specific technology, not to be an elegant piece of programming. The needs of the user should dominate the design of the interface and the needs of the interface should dominate the design of the rest of the system". The user centered design is at the heart of the design process, merging other key principles of system design for diverse users. However, UCD is often said to focus on the typical user and not include atypical users. According to Newell and Gregor (2000, 2002), both the concept of USID and user centered design are similar. The USID aimed at understanding the fact that all systems should include disabled users and treat them equally, starting with those users with extreme requirements. The USID term is a more appropriate term to clarify the importance of sensitive design of a system, ensuring that the system should involve disabled user. In system design, the USID encompasses and extends UCD principles, combining it to provide the best capture for user interfaces, including human factors (Bailey, 1995).

Creating computer games is a difficult task since it involves complex cognitive processes in every development phase (McGuire, 2009). Creating computer games, particularly evaluating the game design is not simple (Korhonen and Koivisto, 2006). First, it requires the contribution of challenging tasks, innovation and creativity, and other critical factors that produce a good game. Second, evaluating users based on their requirements is necessary (Charles and McNeill et al, 2005). This could help to distinguish the differences of capabilities between them. Kline and Witheford et al. (2003) and Kerr (2006) reported that most computer games are not successfully applied to all users, due to the intrinsic, in-game complexity - it is often so high that they could not understand the game play at all. However, some simple computer games could be very successful (Pagulayan and Keeker et al., 2003), probably due to being well calibrated. Overall, as suggested by Kent (2000), "no one wants to read an encyclopedia to play a game" (p. 28). A game player will usually give up playing the game if they could not understand the game play after many trials.

USID Principles	**Component in the HUNGS theory**
Equitable	Perception
Flexible	Feedback Management
Intuitive	Executive Function
Effective	Complex Output Sequence
Tolerant	Emotion and Drives
Efficient	Executive Function or Emotion
Appropriate	Cognitive Model

table 3.2 The Relation of USID Principles and the HUNGS theory

There were seven inclusive design principles adopted by the Center for Universal Design (1995). These inclusive design principles are useful. They provide a consistent explanation, explaining with simple guidelines for enhancing the disabled player's performance. The principles also stress several design aspects, such as information perception, enjoyability, and stress. These features are relevant to computer games design. The seven principles have some correspondence to the components of the HUNGS theory. This is shown in the table above.

Chapter 4

HUNGS Heuristics:Principles and Guidelines

4.1 Introduction

Heuristics evaluation is one of the simplest yet robust approaches to interaction design, acting as a guide for system designers to use in the design process (Badii and Zhang, 2001) including design for interactive computer games (Desurvire, Caplan and Toth, 2004). These researchers believe that heuristics could help them to produce one of the most productive interactive systems for diverse users. In fact, the enjoyability aspect of a game is usually taken into account in sets of heuristics. Inkpen (1997) suggested that enjoyment and fun are two aspects of motivation where game designers should not ignore.

There are not many effective theory-based predictive evaluation methods proposed specifically to evaluate the design of interactive computer games (Desurvire, Caplan and Toth, 2004; Baauw, Bekker and Barendregt, 2005) before the introduction of heuristics evaluation by Nielsen and Molich (1990). According to Schaffer (2008), heuristics evaluation is probably the only effective evaluation approach that is capable to diagnose design problems of a system from the beginning of the design process. If heuristics evaluation is an effective evaluation technique for interactive systems, could this evaluation approach be applied in the context of interactive accessible games, the sound-only games? The answer is yes. Although Malone (1980) has suggested that some popular heuristics-based evaluation focuses on the games design and not the game play, clearly this evaluation technique is beneficial in that could identify highly important requirements of interactive systems (Sanchez and Elias, 2007). Perhaps game designers should consider using heuristics to evaluate the role of game playing to improve game playability and player experiences. If so, this is a very important feature to improve accessibility and usability of computer game systems.

There are several possible downfalls of the heuristics designed by Nielsen. First, the initial version of heuristics is useful to capture necessary features relevant to systems design. However, the heuristics are too broad (Chisnell, Redish and Lee, 2006) and general (Schaffer, 2008) to be applicable to the design of specific interactive systems, such as computer games since general usability heuristics are insufficient to relate to important details of games (Federoff, 2002). On the other hand, Nielsen's heuristics are powerful, and provide an advantage for game interface evaluators. Unfortunately, they do not entirely address important specifics of computer games (see below). Nielsen's heuristics are intentionally designed for use by only professional system developers (Federoff, 2002) and not novice system evaluators (Schaffer, 2008). If so, such heuristics require more expertise to use and are not applicable for novice evaluators.

Despite the immense popularity of computer games, there has been little work yet on creating proper accessible games for visually disabled users. The design is a major issue for most computer games (Kristiansen, 2008). Although the concept of the cognitive architecture itself is complicated (Atakan, 2006), it has proven useful when addressing user requirements in interactive game situations. West et al. (2006) found that the complex cognitive architecture, ACT-R is beneficial when applied systematically to explain the social content of simple games. Eck (2010) further claimed that a cognitive architecture is important to explore cognitive processes when handling, for example, the impact of cognitive overload in computer games. Many additional aspects of accessible games design involve cognitive strain (Albers, 1994, 1997), a stressor that could mitigate the enjoyability and stimulation of games if not well adjusted.

Heuristics evaluation has been recognized as an effective approach that measures the usability design of that computer system (Federoff, 2002; Desurvire et al. 2004; Rocker and Haar 2006; Pinelle and Wong et al. 2008; Bernhaupt, Eckschlanger and Tscheligi, 2007; Bernhaupt and Ijsselsteijn et al., 2008), including the collection of essential information relevant to game design (Fu, Su and Yu, 2009). For example, observing human behavior and emotions is an important consideration. Christina and Wolfgang et al. (2010) have proposed a set of heuristics to evaluate user experiences of interactive games. They argue that heuristics are closely related to user-centered design in the context of computer games. Indeed, the accessibility of a system depends critically on the identification of user requirements (Iwarsson and Stahl, 2003). If heuristics are not used throughout the design cycle, designers may not capture every aspect in the development phase (Schaffer, 2008). In all, heuristic evaluation seems to be an efficient approach since it is often quicker, cheaper and easier to use than other methods (Isbister and Schaffer, 2008).

4.2 The HUNGS Heuristics

4.2.1 Introduction

The HUNGS theory (see chapter three) generates a set of design heuristics that are grounded in theory, namely the HUNGS heuristics. The heuristics were generated based on a user model, acting as a simple framework to guide sound-only game designers and other practitioners to design a potentially stimulating accessible game. Indeed, the HUNGS heuristics could explain and support most cognitive aspects relevant to computer games design. Such heuristics could provide a set of useful criteria to evaluate several computer game aspects, such as enjoyability by optimizing stress level so the challenging nature of the game content would not be destroyed. Overall, capturing complex cognitive processes without integrating relevant cognitive aspects into models and theories could not be possible (Hancock and Desmond, 2001).

Individual differences and disabilities have been claimed to be two important cognitive aspects of interaction design (Adams, in press). Understanding these two aspects will essentially contribute to measuring a player's learning curve and cognitive overload in sound-only games. Indeed, designing sound-based game is a difficult task since perceiving sound-only information will usually involve the understanding of learning, pressure and stress (Wickens et al., 1998; Parasuraman and Hancock, 2001). These important features have been highlighted in the HUNGS heuristics.

4.2.2 Evaluating Totally Lost Games with the HUNGS Heuristics

The present research starts off with the first sound-only game, namely the Totally Lost game. It is a casual sound-only game, initially designed for users with visual difficulties. The game contained two game elements, visual and sound. However, based on the survey questionnaire forms (see Appendix 9.13); our participants suggest that the game is not properly designed based on the consideration of various cognitive aspects. The questions contained in the questionnaire were grouped into different components of the HUNGS theory, and converted into a set of heuristics. This is important so the questions could turn into a more meaningful guide. The guide is known as the HUNGS heuristics. Similar to the work conducted by Karousos and Papaloukas et al. (2010), an accepted questionnaire-based heuristic could further predict game player's experience. A set of heuristics has been crafted to evaluate the Totally Lost games, with 53 items, namely the HUNGS heuristics. The heuristics was generated by the use of questionnaires. The second and third game, namely the Totally Lost 2 and Totally Lost 3 was developed based on user experience and comment from the first version. This will further be discussed in Chapter Five (Methodology).

The Totally Lost games are sound-only games intentionally designed as an assistive interactive technology designed for visually disabled users. Every item contained in the heuristics list was explained based on different scenarios. Scenario-based heuristics could provide a wider coverage of the usability problems (Bernhaupt, Mihalic and Obrist, 2008) and potentially highlight some major disadvantages of previous heuristic evaluation techniques. For instance, the game evaluators need not be expert evaluators (Galitz, 2007) to evaluate the design of such games. Another essential feature of an effective learning game is the potential of contributing sufficient challenges to the player (Malone and Lepper, 1987). Moreover, learning happens when the user deeply engaged in challenging or almost-impossible tasks (Taylor, 2006). Overall, here are the aspects of truly enjoyable games: game type (Dondi and Moretti, 2007), game design and user pleasure produced by game controls (Pagulayan and Keeker et al., in press), and the player's cognitive skills (Kiili, 2005).

The first evaluation of the first game involved six evaluators; two professional musicians and four blind ICT users. The first blind evaluator has extensive experiences evaluating interactive applications and design, and had at least ten years of experience in evaluating different applications, including sound-only interactive systems. The second blind evaluator has substantial experiences in computer games (visual and non-visual games). The two other blind evaluators have much experience with interactive applications, particularly with iPhone applications. Our blind evaluators were blind since birth. The two professional musicians are music performance postgraduate students. Both of them were studying in a British institution. They have the ability of absolute pitch and play different computer games.

4.3 HUNGS: Principles and Guidelines

4.3.1 Categories and Statements

A. The Upper Mechanism (Executive Function) *6* items
A1. The loading time for the game is minimal to avoid frustration.
A2. The game is easy to learn.
A3. New game contents will be updated on a regular-basis.
A4. The game is enjoyable whereby it motivate the player to learn.
A5. Practicing the game for many times will not generate serious boredom effect.
A6. The player's game score increases after playing the game for many trials.

B. Perception or Input process *6* items
B7. The sound cues were well presented in both ears.
B8. The game provides sufficient sound-feedback to replace visual cues.
B9. The game offer different background music according to the difficulty levels.
B10. The background music matches the game play.
B11. The volume of the instructional sound and background music is optimised appropriately.
B12. The game provides sufficient sound-based instruction.

C. Feedback Management process *5* items
C13. This game provide immediate score feedback.
C14. The player has necessary perceptual skills to respond to the game.
C15. This game will respond to the player immediately.
C16. The game provides adequate game-feedback for the players.
C17. Sound cues are presented appropriately to the left and right ears.

D. Working Memory process *5* items
D18. The memory requirement of this game is fine.
D19. Not too many sounds (burden) are presented to the player.
D20. Every item in the game provides different sound attribute to reduce player's memory load.
D21. Memorizing the game play and game map is simple.
D22. The player does not need store too much information in their mind when playing the game.

E. Emotion and Drive process *6* items

E23. The game allows the player to choose few levels of difficulties.
E24. The game does not contain cheat codes that reduces motivation.
E25. The players can choose to protect their privacy in this game.
E26. The game is not confusing.
E27. The play is motivated to play the game again.
E28. The game offer relaxation and pleasant game environment for stressed players.

F. Cognitive Model process *5* items
F29. The game provides an automated and accessible sound-based menu.
F30. The game provides an interesting and understandable storyline.
F31. The game design was well presented, based on a cohesive game structure.
F32. The game provides sufficient support for the blind players to play it.
F33. The in-game overloads were balanced to overcome player's limitations (i.e. not too easy or hard).

G. Long Term Memory process *6* items
G34. The game does not require too much sound knowledge from the player.
G35. The player does not need to learn a lot and recognize all sound attribute to play the game.
G36. The user-knowledge requirement of this game is well designed.
G37. The player could play the game properly without long term knowledge of computer games.
G38. The game does not require blind players to memorize too many sound cues.
G39. The game does not require long term planning in order to play it effectively.

H. Complex Output Sequence process *4* items
H40. The player could achieve greater skills to win the game after playing few times.
H41. The player could achieve various cognitive skills from playing the game.
H42. The blind novice players have sufficient skills to play the game.
H43. The game supports complex response from the player.

I. Output process *3* items
I44. The game controller is feasible and easy to use by all players.
I45. The player has necessary game skills to perform appropriate response.
I46. The game allows the player to make simple or complex responses.

J. Enjoyability, Stimulation and Rewarding-system *7* items
J47. The game does provide sufficient time for players to complete/win it.

J48. The game offer strong rewards to motivate players to play it more.
J49. The game will positively boost the player's level of adrenaline upon playing.
J50. The game is addictive and competitive, where the players could compete with other players.
J51. The player could score easily if they completely understand the game play.
J52. The game system should provide some reward for players who know when to logout from the game (health conscious).
J53. The game offers profitable reward for game designers who could attract many players to play.

4.3.2 Evaluating Sound-Only Computer Games

Full details of the sound-only games are found in Chapter Five.

The design of the Totally Lost 1 game is not encouraging because the game was design was based on purely pragmatic suggestion from users, in which the game was written based on non-inclusive design and only for research purposes. The interface, functionality and the game design of the Totally Lost 2 game were evaluated by the evaluators, through the application of the heuristics. Few professional evaluators were recruited, and have generalized their qualitative and professional justifications of the Totally Lost 2 game based on the heuristics. They suggest the Totally Lost 2 game is a learning-based game where it involves complex cognitive process. One requirement of the user when playing the Totally Lost 2 game is a wider cognitive capacity. The game requires too much concentration. Critical concentrations from the user could maintain an optimal state so they could perform effectively (Gaillard, 2008). However, too much concentration in computer games produces cognitive overload, and will usually reduce cognitive capacity (Mayer and Moreno, 2003). If the player could concentrate under stress and pressure, they could tolerate such stress and achieve higher game scores every attempt (Gaillard, 2003a, 2003b). Other motivational strategies involve providing more stimulating content of the game (Gaillard, 2008).

The professional evaluator's (two blind computer experts, two professional musicians and two game usability experts) set their qualitative justifications of the Totally Lost 2 game based on the nine components of the HUNGS theory, as follows:

1. Executive Functions support: The game is not too difficult to understand although it does require the recognition of comprehensive information. Playing the game is not boring and would be able to increase users' learning experiences. Although the overloads of the game were optimized appropriately and provide sufficient potential help (sufficient sound cues) to assist visual disabled players when dealing with other relevant executive function problems, such as skills, experiences and organizational skills, however the enjoyability of the game was rated as moderate because the difficulty of the game is too high. Player's could not find any solutions to win the game, unless they seriously concentrated on the game play. In addition, computer games that require extensive amounts of practice which will generate significant levels of boredom and fatigue (Keller, 2009). The game also require additional competitive and challenging feature so serious players will enjoy playing it. To date, only one professional musician (evaluator) could win the game, in the twenty-seventh trial.

2. Perception or Input Functions support: The perception of sound cues were well presented in both ears. Based on the game, the intensity (volume) of the background music was well optimized. The professional musician justified the rhythm of the background music as acceptable since the music produces an enjoyable feeling and challenging mood for them. The two musicians indicated the importance of the music of a game. According to them, "the game is not fun if the music could not attract them". The instructional sounds in the game are clear and sufficient whilst not impairing the player's sound sensory and perceptual skills, so that they can play the game well. Sound cues were well presented. However, they suggest that there were too many sounds presented in the game. They could only remember all types of sound after ten trials. Anyway, the game is challenging to a stage where players would be able to selectively filter unnecessary sound cues after ten trials.

3. Feedback Management support: The game elements were well presented (instructional sound cues and game score). The sound feedback is sufficiently adequate that would allow players to increase their learning experiences. A significant amount of practice with the game will increase the accuracy of auditory perception when playing the game. However, regular practices should decrease the challenges and enjoyability content of the game play because "no one wants to play a game where the most difficult stuff is first and then everything gets progressively easier" (Newman, 2008, p.104). This indicates that the practice effect will improve auditory precision, generating the automaticity effect and bypassing various overloads, and will subsequently reduce the game performance, unless the game could automatically update additional stimulation to the game content (overloads) on a regular basis.

4. Working Memory support: The stress level of the game is not optimized appropriately, to be at a level where the memory store is still an essential component. In other words, game players still need to store substantial information in their working memory when playing the game. However, this effect will be mitigated with practice. The game play is sensible and will not require too much memory when users are familiar with the game. This was obvious when the professional musician could only memorize the roadmap after playing the game 20 times. The optimal level of memory requirement and skills from the player could be enhanced with game practice.

5. Emotional support: The game is fun to play. Though it is not a simple game, it is challenging especially when players are trying to achieve higher game scores every attempt. Although the direct influence of challenge has improved the enjoyability of playing the game, yet it still produces frustration when players were not able to complete the game. Anyway, the game scores vary when played by different game players because emotions are varied from person to person. They are also subjective and is relatively difficult to measure (Cacioppo and Gardner, 1999; Adams, 2007; Jeong, 2007). Those players who do not have sufficient patience will not achieve high game scores or win the game. Overall, the game is satisfying but should be calibrated so the in-game stress level is optimized.

6. Long-term Memory support: The game is very competitive such that the players will tend to want to continue playing the game to achieve higher game scores. However, they have to memorize all the sound cues presented. This is clearly an important aspect for an acceptable game, especially for visually impaired users who require substantial amount of memory capacity to store information in their long term memory while playing a game. Memorizing the roadmap and all keywords contained in the game may produce serious overload effects, such as frustration. Paradoxically, this may contribute to effective learning, increasing their memory skills and memory capacity.

7. Cognitive Model support: The game is well supported by a coherent cognitive model that may effectively enhance sighted and blind player's understanding of the game play. The game contains an attractive storyline and role playing, allowing the user to understand the game content easier, increasing the realism of the game (Shapiro, Herborn and Hancock, 2006), stimulating the enjoyability and emotions of the game for the user (Schneider and Lang, 2004). The information is well presented in the game. The design and layout structure of the game is accessible.

8. Output support: This game is complex and would easily attract our blind player's interest because important users (e.g. blind users) are usually motivated by games playable by sighted people. They would be able to respond immediately to the game within few practices.

9. Complex Output support: The players responded well to the complex output of the game. Since the game is not too difficult to understand, players could produce some complex response in order to complete the game. All the participants have no problem controlling the game controller (mouse) to play the game.

10. Stress, Stimulation and Rewarding-system support: Overall, the Totally Lost 2 game has the potential to meet all important user-sensitive and inclusive design requirements of good design and has provided a challenging, enjoyable and competitive gaming environment for all the evaluators. The game has encouraged them to try harder to achieve higher game score every attempt. However, it is often difficult to estimate and meet different players' emotions since emotion is a relatively difficult aspect to explore. Other stimulating aspects have been investigated with usability tests. Using a mouse as the game controller is acceptable. It helps blind users to play the game since a mouse is feasible and relatively simple option for them to use. The rewarding-system is a highly beneficial aspect to measure profits and rewards. Designer's requirement must be considered (Persad and Clarkson, 2005). Whilst, game players can be considered as information users, they will usually pay more attention to help design a better game if the game rewards them.

4.3.3 Evaluation Outcome: Totally Lost 3 Game

The Totally Lost 3 game was developed based on the concept of Totally Lost 2, except this time, the heuristics was used as a part in the design process. The difficulty level of Totally Lost 2 was calibrated based on our evaluators' suggestions. Totally Lost 3 was designed to aim at optimizing the level of stress to an appropriate level whilst the complexity of the game is retained. Thus the game has some improved features. First, the sound-based in-game tutorial session is more interactive. Second, the game menu is automated (loop-based), meaning that the player only needs to listen properly to the instructions and select an option with one mouse-click. Third, some sound features were reduced so it will not overload the player's working memory. Fifth, the loading time of the game has been reduced.

The same six professional evaluators who evaluated the Totally Lost 2 game were invited to discuss their experience of the Totally Lost 3 game. Their qualitative evaluation and suggestion is as follows:

1. Executive Functions support: The game is not too difficult; they rated the level of difficulty as 6/10 (moderate). The time-based aspect of the game (adjustable speed) is a challenge for them. When the game speed increases, the evaluators find it motivating because the quicker they could collect the in-game items, the more scores they could achieve. These are the game aspects that could increase their cognitive skills. Playing the game is not boring. The game does not need extensive amount of practice to understand. Instead, they could play the game with no explanation given. The evaluators demanded the implementation of a few more game difficulty levels. They believe the game will produce boredom or fatigue effect in long run, unless new game contents are updated from time to time. The loading time in the game is properly adjusted. They could restart the game immediately.

2. Perception / Input Functions support: The game presented sound cues properly in both ears. The changing background music is well presented. The background music is enjoyable, providing some sense of motivation for the professional musician evaluator. The evaluators could tell if their earphones are set to correctly for both ears. The number of sound items available in the game will not overload the evaluators' working memory. They could remember all types of sound properly.

3. Feedback Management support: This feedback in this game is quite different when compare to the Totally Lost 2 game. Here, the music changes, telling the player they only have ten seconds to play before the game ends. In addition, a voice appears, announcing time left. This is seen as a very positive change in the game, when the player successfully collected an item, a different sound appears. This is a very important aspect for sound-only games. The players were excited when more sounds were presented. Perhaps, too few sound items are not proper features for enjoyable games? At the very least, the game has optimized its intrinsic overload (compared to the Totally Lost 2 game) so the game is not too hard and or too simple.

4. Working Memory support: The stress level on memory of this game is well optimized. The evaluators believed that this game is suitable for all players. The game does not place too much demands on the user's working memory. The players do not need to play the game for many trials before understanding the game play. The game imposes only moderate stress, such that playing the game does not require too much memory.

5. Emotional support: The evaluators enjoyed playing the game, more than the Totally Lost 2. They could continuously play the game without taking a break. Our heroic evaluators suggest the time-task and the increase of in-game speed are the most challenging aspects of the game. However, the evaluators suggest that changes of emotion may produce a negative impact on their game scores.

6. Long-term Memory support: This game uses different approaches when compared to the Totally Lost 2 game. The game requires only moderate long term memory capacity from the players. Our evaluators could remember all the sound elements in the game. In fact, the players have to memorize all the sound items in the game in order to play it effectively. Every game component contains distinctly different sound effects, making it easier for the user to memorize the differences.

7. Cognitive Model support: The game was designed based on a coherent model. There is a sound-based tutorial session implemented in the game to guide our users to play the game more effectively. In fact, the tutorial could prevent many usability and game play problems. All the evaluators suggest that the in-game tutorial could guide them to understand the game play more proper.

8. Output support: Although our blind evaluators use a keyboard for their work task, they could use the game control (mouse) to play the game immediately after participating in a mouse tutorial session. They would be able to respond to the game immediately within few trials.

9. Complex Output support: The participants responded well to the complex output of the game. Our evaluators could obtain necessary skills to achieve higher scores every attempt. After understanding the game play, they start gaining higher scores. Perhaps they found necessary complex skills to support them to achieve higher game scores.

10. Stress, Stimulation and Rewarding-system support: The Totally Lost 3 game met the user sensitive inclusive design requirements. This game encouraged blind users play. Our evaluators have suggested that this game is very interesting. They assumed that they could perform better if they were given an opportunity to compete with other players. If this feature is a part of enjoyability, then it should be considered by game designers in the context of computer games. On the other hand, some of them suggest they could perform better if they were given some reward (e.g. money) in return for achieving highest game score. The time task is also an important aspect, providing a very competitive environment for them when competing against the time.

Chapter 5

Methodology

5.1 Introduction

Very little is still known about the computer game players' experiences (Clarke and Duimering, 2006). So, one of the aim of this research is to provide a better understanding of how to design and develop accessible and acceptable sound-only computer games, based on the game player's motivation and learning experiences. As a result, game designers will learn how to design better, acceptable and enjoyable sound-only games for diverse users, including those who cannot use their vision to play, due to disability or circumstances. In particular, two performance diagnostics (learning curve and cognitive overload or secondary task) were used to explore human cognitive processes that are relevant to the playing of sound-only games and to the diagnosis of design problems for such games. The two performance diagnostics have not been well established in the context of interactive computer gaming performance. Due to the immense popularity of games playing, it is surprising that few sound-only games are popular with users (Archambault and Gaudy et al., 2008). Therefore, the approach taken here is to explore sound-only game performance as a basis for better understanding game acceptability and to design games better.

Since different combinations of the attributes of users exist, games and systems should call upon different human and distributed cognitive processes, so it is important to understand those processes to design better computer games and systems that meet users' requirements (Card, Moran and Newell, 1980). A long tradition in cognitive psychology has been to use performance diagnostics that help to understand human cognitive processes and performance better. For example, Roberts and Sternberg

(1993) used the diagnostic of reaction time (RT) additivity and non-additivity. RTs that were additive were seen as influencing different processing stages whilst interacting RTs influenced the same stage. Thus, they could use the pattern of results to infer the underlying processing stages. A number of such diagnostics were used. In memory studies of recognition failure of recallable items, the ratio of recognition misses to recall hit is a suitable diagnostic of retrieval processes (Tulving, 1983). When exploring the implications of environmental stressors such as noise, heat etc, the identification of underlying psychological processes has often been based on the observation of interactions (or not) between different stressor effects (Broadbent, 1971).

The main research hypothesis, however, is that traditional laboratory results would not necessary applied to the interactive gaming context in exactly the same way as in their original context. This is clearly an important question for a truly enjoyable game, although as current, prominent user modeling theories such as ACT-R, SOAR and Simplex Two predict a power-law of practice and not an exponential law.

5.2 Sound-Only Computer Games

5.2.1 Sound-Only Accessible Computer Games

Two sound-only games that differ systematically were initially used in the experiments. The purpose is to choose two different sound-only games, examining which has more potential as a starting point for this research, to produce an effective way to design an acceptable and enjoyable sound-only game. The Drive game is an existing sound-only game designed for research purposes and for people to play it as an interactive game, whilst the concept of the Totally Lost games aimed specifically at measuring the feasibility of a range of methodological options related to this research. Initially, the existing sound-only game (Drive) has been chosen for initial evaluation. It is difficult to design and calibrate the design of a good non-visual computer game. Interestingly, good games are stimulating (Ladd and Jenkins, 2010). Thus, a bad game will negatively impact learning and other relevant cognitive skills such as problem solving (Schell, 2008).

The Drive game was chosen to be a part of the initial testing. The most important part of the game is that it contains simple commands and controls (e.g. voice buttons, simple keyboard commands, etc.). Such valuable features play an important part in the inclusive design. Initially, the game was designed to be played by children so the game content is rather simple. However, due to its simplicity, the Drive game was seen to be demotivating and could reduce players' desire to play after many trials. This is reported by the participants who have taken part in Experiment One and Two (see Chapter Six). They also reported that controlling this game with a keyboard is too slow for them to achieve higher game scores since they have to remember the position of the command keys on the keyboard (or stare at the keys consistently). Since the game play of Drive is too simplistic and could not generate maximum enjoyability for expert players, in addition to constructive evaluation (user-centred) with the participants in every experiment phases, a new game was developed, namely the Totally Lost 1 game.

The Totally Lost 1 game was developed for practical use as an evaluation tool. It is by design a research-based game, and has not been commercially advertised. The design of the Totally Lost 1 game is very similar to Drive where simple game features were provided. The game is playable with a computer mouse. The computer mouse setting was set to default for all sound-only games used in this research. This means that loading any of the games in any computer system will achieve the same mouse sensitivity. By doing this, the game results (scores) obtained from participants in all the experiments will be more accurate. The game was tested in different phases by different participants. Firstly, it was tested with some participants with artificially constrained vision (blind folded). This method could investigate player's cognitive performances (learning curve). Second, the game was calibrated on a more pragmatic basis, based on player's experiences (user-centred design) and a question-based set of heuristics. The participants suggested that the game play is still simple, similar to Drive, where it could not stimulate a player's desire to play. They suggest including some important game features, such as guidelines and an interactive storyline. These are the missing features causing the participants to be confused with the overall game play. So, a second version of the Totally Lost game was produced (Totally Lost 2).

The Totally Lost 2 game was designed and developed as a second game prototype. Additional game features such as the game tutorial and a storyline were added into the game system based on the players' demand from Totally Lost 1. The game tutorial is important so the players' will find the game more meaningful whilst increasing the intrinsic challenge to the game. On the other hand, a valuable storyline can promote critical understanding and entertain the player. These are also important game features. The game was tested with both sighted musicians and blind people as participants. Some novice players complained that the game is too stressful. The participants' said that the game requires too much skill and concentration, at a stage where only serious players could play it. It was therefore decided that the complexity of the game should be reduced.

Thus, the Totally Lost 3 game was developed. This game was developed based on players and evaluators suggestions and feedback after playing Totally Lost 2. Based on the evaluators' suggestions, the game is fun but lacks competition features. They prefer competing against each other rather than playing it individually. So, as suggested by the participants in Experiment Six, the Totally Lost 3 game was tested with a more competitive approach; the blind participants were asked to sit together and play the game next to each other with different computers in Experiment Seven. Obviously, as predicted, players should feel motivated and willing to work harder in order to achieve the reward. To do so, the players from Experiment Seven were told that top scorers from this group will be given some reward by means of money.

Significant increase in performances by the participants could be seen when the players were rewarded. Interestingly, from observation, reward is another feature that will increase players' game performance and their intrinsic challenge. This is another important feature where game designers should include as a part of the game play, in order to attract more players..

Sound Design There are three types of sound available in each game to assist the players to play the game effectively. The first type is known as the instructional sound. The purpose is to provide a simple game guide, instructing the player throughout the game play. The instructional sound was added to the game menu, and in the game. The second sound-type is the sound object. Every object will have a sound, telling the player to understand them based on that particular sound. For example, a speed booster will have a beeping sound. The beeping sound will appear when the player is approaches it. Third is the sound score. A voice will appear at the end of every game session, telling the player the game is over whilst including a voice-based game score.

Scoring System The Totally Lost games provide a simple sound-based scoring system. When the player successfully collect an object in the game, e.g. successfully collecting water drip in the Totally Lost 3 game, one point will be added to the score system. If they collect another drip of water, another point will be granted. When the game is over, the total score will be announced by a voice (sound score), and published on the screen (visual) so the author will know the players score.

Keys The Totally Lost games are playable with a computer mouse. Every player will use the buttons available (with the mouse) in order to play the game. For instance, in the Totally Lost 3 game, the player will have to utilize all the keys, and moving the mouse to the correct direction to achieve higher game scores.

The games (see this Chapter) and experiments (see Chapter Six) will be discussed further.

5.2.1.1 Drive

Drive is an existing, open source sound-based game developed by Tol, Huiberts and Verweij (2002). This player controls a landing shuttle at maximum speed. As they progress through the game, they need to collect speed boosters to gain additional game points . Players are required to collect and activate boosters (collected) so they can increase the shuttle's speed. Simple controls are provided. Press and hold the up-cursor key for acceleration. Press the spacebar to stop the shuttle. The left-cursor key is used for collecting the boosters. So, when the players hear beeping sounds (boosters), they should stay alert to use the left-cursor key to collect them. They can active the boosters to increase the speed of the shuttle by hitting the right-cursor key on the keyboard. The boosters are stackable up to three times before activating them. Feedback is provided in the form of a female voice. The game provided three minutes in total for the player. Then, the female voice will announce their total score accumulated. Full details are available at http://www.audiogames.net/drive.

5.2.1.2 Totally Lost 1

Totally Lost 1 is a new, brief and simple game that is intended to be accessible to players with limited vision, due to disability or circumstances. As a sound-only navigation game, it involves various cognitive skills, such as user memory and attention. Game players navigate around a labyrinth using a mouse, based on acoustic information, accumulating points for progress and avoiding obstacles found in the maze. The players will be given more game point as they moved their mouse cursor through the labyrinth. More points will be given as they progress within the time given. They must aim to leave the labyrinth successfully in the time given (a total of 1 minute). When the time runs out, the game scores appear. There are seven pouches in the game, waiting for the players to collect. The player have to listen carefully when collecting the pouches since every pouch contain different keywords (i.e. a, b, c, 1, 2, 3 etc). When they approach the pouch, picking them up with the mouse pointer, a voice appears, revealing the keyword contained in the pouch. Our players have to remember all the keywords from the seven pouches, and key the words in when they reached the check point. The computer screen was on but the players could only see the mouse-cursor and game scores, and no additional information.

5.2.1.3 Totally Lost 2

Totally Lost 2 is an extended version of the Totally Lost game, designed based on the user-design and suggestions approach. The differences between the first two games are a slightly different storyline and additional interactive features. The Totally Lost 2 game has a main menu where players can choose with their mouse cursor, to participate in the tutorial session or playing the game. The storyline of this game starts in a burning house where the players have to survive and leave the house using a mouse within two minutes. Each player is given five lives. This is how it works: Touching the wall will reduce one life, and subsequently return to the original spot (namely the teleporting spot) of the game. As they progress through the game, they have to avoid touching the burning wall. They also have to collect the life booster based on the available sound information to increase their life. Every life booster will increase their life by one. They also need to collect the time boosters available to add thirty seconds to the time elapsed. The scoring system for Totally Lost 2 is very straight forward. The player will start scoring the game points by collecting sound-items found in the game. For instance, collecting the time booster or life booster will collect one additional total point. So, they need to collect as many in-game items as possible. Passing through the door (additional points will be given) to the next stage will help the player to accumulate additional game points. The concept of this game is very similar to the first, where the players have to collect seven different keywords from the key pouch to unlock every door. When reaching the checkpoint, the player will be asked to enter the seven keywords to win the game. No additional information was given besides a blank screen.

5.2.1.4 Totally Lost 3

Totally Lost 3 is a simple sound-only game where the player needs to guard his/her fish pond from the invasion of some strangers who have plans to kill all the fish with toxic water. This game is intended to be played by people with visual limitations. The game is aimed at several aspects of human factors, such as user memory and attention, motor skills and perception. Similar to the two earlier games, the game is playable with a computer mouse. This game is an expanded version of the Totally

Lost 2 game. The story began in the same burning house. After many years, the house was burned down entirely. So, the home owner built a fish pond inside the house compound and sells expensive fish to the customers, hoping to collect enough money to rebuild the house. In this game, the player has one mission that is to guard the fishpond from invasion by nearby fishery competitors who have intensions to kill all his fish for their own business profit.

In this game, players have to listen properly to the location of the water drops, either in the left or right side. Simple controls are provided. The player must listen properly to the position of the toxic water drops and remove them by moving the mouse to the correct direction (left or right). Sometimes, the stranger might throw different toxic industrial waste into the pond to kill the fish quicker. Therefore, players have to tap either on the left or the right mouse button accurately based on the changes of the sound position to remove these waste. By clicking properly on the mouse button based on the location of the sound, the player start gaining game points. They will also gain additional game points if they successfully collect the time booster. Since the speed of the toxic water will gradually increase as time passes, players should try to extend the time by tapping on both mouse buttons at once when they hear the sound of a ticking clock. In summary, there are two different types of toxic waste which the player must prevent from getting into the fish pond; (1) toxic water and (2) toxic industrial waste. Both of these will produce different sounds, so players must pay attention when playing the game. Although the game play is simple, however, if they did not managed to stop the toxic waste from flowing into the pond with their mouse controller, then the elapsed time will subsequently be reduced. A total time of 2 minutes will be given to the players before the game ends. They may increase the elapsed time by 5 seconds every time they have successfully collected a time booster. No additional visual-information was given besides the score bar and the timer.

5.2.1.5 The Feasibility of Computer Mouse in Sound-Only Games

A computer keyboard was originally used by blind people as their primary input device of computers (Baptiste, Tornil and Encelle, 2004). To increase the accessibility of computer keyboards, many approaches have been proposed. For instance, Kitsana and Innet (2007) have developed a new layout design of computer keyboard for blind people. The design of this special keyboard is tailor made for blind people so they can access multi-languages and Braille. However, many blind people still find it difficult to use a computer keyboard when navigating graphical interfaces (Baptiste, Tornil and Encelle, 2004), particularly in interactive games since ”functions not available through keyboard commands will not be available to people with disabilities" (Gunderson, 2003, p.478). Furthermore, full use of a mouse controller in many interactive systems and graphical applications such as computer games is unavoidable (Gookin, 2007). On the other hand, blind gamers must train themselves to memorize all functional keys of a keyboard before learning and enjoying playing the game since most computer games require many keys, unless a device (e.g. mouse) could be a substitution for the keyboard. Furthermore, new generation technologies such as the iPhone requires the use of a navigational touch panel for playing games (currently not fully accessible for people with various cognitive impairments yet). The iPhone requires finger movements to navigate around the screen. A computer mouse is currently the best substitution to navigating with the finger. If so, game designers should also consider other gaming controllers that are beneficial for blind users.

According to Colas and Monmarche et al. (2008), blind users should have different alternatives to control assistive technologies just as long as it is convenient for them for navigation. Pagulayan and Keeker et al. (in press) suggest using alternative controllers rather than a keyboard in computer games. The usage of a mouse is so close to a keyboard, it is usually considered as the most common alternative to the keyboard. It could also be used effectively in different interactive applications such as browsing the website or operating different multimedia applications (Colas and Monmarche et al., 2008). Besides its simplistic usage and operations, a mouse provides bi-directional navigation that makes it an extremely feasible option for most multimedia applications such as computer games (Miyashita and Takagi et al., 2007). Current findings from this research have collected substantial information of mouse usage from eight blind computer users. The blind participants were asked to participate in a simple mouse training session, where they have to complete five different training tasks using a computer mouse. The mouse tutorial is a computer application used to guide the blind participants to use a mouse. They are required to participate in the mouse training (e.g.moving the mouse to the left, clicking the right mouse button, etc.) based on the sound-only instructions given. They have suggested that a mouse is an important input device that could provide immediate action and feedback for them when playing games. Furthermore, they only need to participate in a five minutes mouse training session to use it. In the training, they were asked to navigate around a simple sound-based interface with a mouse. Overall, a mouse is a feasible option for blind computer users.

5.3 Experimental Approaches

5.3.1 Introduction

To achieve all the aims of the research, two relevant performance diagnostics and other methodological approaches (such as user sensitive inclusive design, heuristic evaluation and participant's self-report) that are relevant and valid in the present setting of sound-only games, and that would enable different participants to experience and comment on the game in a more enriched and varied context. Additionally, the two chosen approaches were measured in various ways to test if they could produce valuable contributions in the present context. Third, perhaps more ambitiously, the chosen approaches will be identified if they will help to understand the psychological processes of game players and the implications for the game design.

These two performance diagnostics (learning curves and cognitive overload) will be tested for feasibility in order to caste light on the cognitive requirements of the participants. Both diagnostics considered here was proven helpful, the first for mainly practical reasons, the latter for both theoretical and practical reasons. As a result of this work, both the design of the game for future testing and our evaluation methodology were improved. Other relevant experimental approaches involve powerful methodological techniques to evaluate the game design itself, similarly, the heuristic evaluation as initially proposed by Nielsen (1993) and the user sensitive inclusive design (Newell and Gregor, 2000). These approaches would assist game designers to typically focus on user-based design when dealing with diverse users, particularly disabled people (Hartson and Hix, 1989; Shneiderman, 1992; Preece, 1994; Newman and Lamming, 1995; Helander, Landauer and Prabhu, 1997). It could sufficiently help to evaluate the games design to capture the user's understanding and expectations.

Understanding players' cognitive processes is not a simple task. According to Krippendorf (1989), the design process was defined as a "circular cognitive process that may start with some initially incomprehensible sensation, which then proceeds to imagining hypothetical contexts for it and goes around hermeneutic circle during which features are distinguished - in both contexts and what is to be made sense of - and meanings are constructed until this process has converged to a sufficiently coherent understanding" (p. 13). It is important to completely understand the capabilities and limitation of activities of users to develop a new effective strategy that would stimulate the design skills and learning processes of the designers, practitioners and users. If so, the understanding of the intended user's cognitive process and the application of the resulting concepts to games design are both essential.

5.3.2 Participants

A total of 62 different volunteer participants participated Experiments One to Eight (39 sighted non-musicians, 15 professional musicians with the ability of absolute pitch and 8 blind users), and ninety-nine volunteers (some have participated the experiment sessions) were recruited for the game-usability and game play discussions. Similar to existing e-learning based systems, the present research does not focus on gender differences since computer games (including educational games) is important for both genders, and should be designed for all (Steiner, Kickmeier-Rust and Albert, 2009). Although male participants play computer games extensively and for longer periods of time (Bonanno and Kommers, 2005; Phillips and Rolls et al., 1995), there are some evidence that female participants will still perform similarly (Steiner, Kickmeier-Rust and Albert, 2009) or better for certain games (Passig and Levin, 1999). Participants of age ranged from 18 to 50 were recruited. The participants were informed that their data would be treated confidentially and that they could choose to refrain from any participation at any phase of the experiment.

5.3.2.1 Sighted people (blind folded)

The initial phase of the experiment session has recruited 39 blind-folded people, namely the artificially constrain the vision of participants. They were randomly assigned to all experiment sessions conducted. The learners and students are at different levels in the educational institutions. Some sighted participants are currently working. All participants in this group have no experience with any musical instruments. Most of them do play computer games in which some are expert computer gamers.

5.3.2.2 Sighted Musician with Absolute Pitch

There were 17 volunteer professional musicians recruited to participate in experiments to test our sound-only games. All the professional musicians are higher education students from different British institutions. A few of them are postgraduate music performance students. The remaining are undergraduate music performance students. They all have absolute pitch. Absolute pitch (or perfect pitch) refers to the accuracy to identify musical pitch and notes, and to have relatively good long term memory capacity (Randel, 2003) dealing with sounds and music in any sound-only environment

. Therefore, they have superior and more sensitive sound perception and processing skills compared to sighted non-musicians.

5.3.2.3 Blind people

There were 8 blind volunteer participants from the Malaysia Institution for the Blind have been recruited. All of them have been blind since birth. Their blindness level is severe to an extent where they could only identify the presence of light. So, their field of vision is very restricted. They are expert computer users who use a personal computer for work every day. In fact, they do have very good memory capacity. All of them are very interested in computer technologies. So, they are considered as motivated computer users who use the computer for work purposes every day.

5.3.3 Participants' Self-Report

Participants' self-report is considered as one important approach when evaluating the design of a system, particularly an inclusive system. According to Dillon (2001), evaluating the design of a system should be based on critical understanding of the user experience. It will help to generate a clearer picture of user needs and preferences. The self-report approach has encouraged valuable yet profitable (Polit and Beck, 2007) evaluation techniques that allow game designers to saliently understand the complexity of the sound-only game they have developed. However, the self-report approach would require careful consideration (Rand, 1999) since the self-report is one of the sources that could critically uncover a participant's mental processes against the validation of useful criteria, such as the user's specific needs. It is also important to evaluate the system appropriately based on the personal assessment of the participant.

There are several self-reporting sessions conducted between the designer and users in every design and development phase. Visually disabled users are rather sensitive to auditory overload (i.e. noise) and that factor would normally require careful consideration in the design of a game. The first session was undertaken based on the first version of the sound-only game conducted with artificially constrained vision participants. This would help to produce a more user-oriented sound-only game that will not impair participants' aural perception and game experiences. Further experiments and evaluation will be based on the next games.

The self-report approach has been used in every phase of this work, acting as a cyclic evaluation process. The first version of the Totally Lost game was developed based on a non-inclusive design approach. According to Sommer (1983, p. 7) and Imrie and Hall (2001, p. 19), the non-inclusive design focuses on "the style and ornament of the system which stresses the owner as exclusive client" for that particular system. The game was tested and evaluated with a group of 50 participants. Some of the participants have contributed valuable suggestions and feedback. The second version of the Totally Lost game was pragmatically developed based on the inclusive design principles. Inclusive design is important in the design of a computer game since the game system is intended to be "usable by as many people as possible, including people who are older or disabled" (Abascal and Nicolle, 2001, p. 3). In this phase, the heuristic evaluation along with the participant's self-report was used to evaluate the game design. The second set of participants' self-reports has been used in the development phase as a supplementary evaluation technique to provide further analysis of the design of the game. This is important to evaluate the usability and satisfaction (enjoyability) levels of the players when playing the game. The third phase, perhaps the most important phase of self-report evaluation was conducted with blind participants to understand their game requirements further.

Finally, an additional participant's self-report (personal assessment) was included in the experimental approach to provide a more methodologically sound and concrete evaluation of the sound-only games designed. This approach is important to judge its feasibility when evaluating the games. The personal assessment approach is also important since it will be able to identify the relationship between what the participants say (self-report) about a game and what participants do (performance) with the game. Significant divergence can reflect, in part, the level of insight and awareness of the participants (Adams, Langdon and Clarkson, 2002; Adams and Langdon, 2004). If so, then the development of the sound-only game should include measures of both self-report and performance to capture the best outcome for this research. However, designers need not only to develop the ability to design better quality accessible games that are both acceptable and enjoyable for a spectrum of users but also help to optimize their stress level. Therefore, the participant's self-report session will take place as an integrative process in the whole design. This is beneficial to help understanding the user as the first priority and to enhance their game experiences.

5.3.4 Questionnaire

There were 20 questions in the questionnaire form (see Appendix 9.13), distributed to every participant after playing the games. The purpose of the questionnaire is to evaluate further about the users preference and their suggestions of the game (preferred game type, games design, game play, interface etc.). The design of the questionnaire focuses on the user, their preference and their motivation when dealing with the particular game. With this questionnaire, the participants can judge the game effectively (user performance and game performance). They can rate the game (based on scale 1 to 10), evaluating the game system based on their preference. On the other hand, the questionnaire offered the most valuable way to gather primary data such as the users information and their view. This questionnaire was also produced to analyze the research aims and objectives.

5.3.5 Performance Diagnostics

5.3.5.1 Introduction

The notion of diagnostic measure was introduced, defined here as the psychological valid variation of extrinsic game features to generate insights into the psychology of the users and their requirements. Two performance diagnostics were chosen to draw upon two well-known sets of findings from cognitive science that have, nevertheless, not been well established in the context of interactive computer gaming performance. The two diagnostics are the learning curve and cognitive overload. Both have substantial research literatures to support their use.

The investigation of the human learning curve has both a long history and substantial current activity (Blackburn, 1936). The typical form of the learning curve is the power-law of practice. It is perhaps not surprising that performance on most tasks increases with practice. What is surprising is the apparent ubiquity of this power-law of practice across diverse tasks and contexts and wider (Ritter and Schooler, 2002; Alderson, 2008). However, even this apparent ubiquity has been strongly contested by a major, recent survey of learning curve data that concluded in favour of an exponential law of learning (Heathcote, Brown and Mewhort, 2000). They present substantial evidence in support of an exponential law of learning. This is clearly not a dead issue and also has not been explored in the context of the interactive accessible games.

But will either the power law or exponential law be found in this context? At the very least, interactive games should be much more fun than laboratory experiments! If learning follows an exponential curve, then learning is reflected to a fixed percentage of what remains to be learnt. If learning follows a power law, then learning slows down (Ritter and Schooler, 2002). If so, that difference in fun levels could motivate players to keep learning to play and so be reflected in the profile of their game performance. Perhaps this notion implies an exponential function for truly enjoyable games! Either way this is clearly an important question (Hung and Adams, 2010), as current, prominent user modelling theories predict a power-law of practice not an exponential law in most work context, or probably for different reasons, explained in existing theories such as ACT-R, SOAR, and Simplex Two. Evidence from computer gaming would extend or provide limits to their explanatory contributions (Anderson and Lebiere, 1998; Adams, 2007; Jones, Lebierre and Crossman, 2007).

5.3.5.2 Learning Curves

The first choice of diagnostic is the learning curve, mainly for two reasons. Firstly, game playing typically involves substantial amount of practice and learning. Simply investigating new users would not necessarily generalize to more practiced users. Second, many studies in cognitive psychology recruit naive participants (Kantner and Rosenbaum, 1997) and so they underestimate the role of learning. Both the problems should be avoided. An important aspect of user performance is captured in the concept of the learning curve. The existence, shape and magnitude of observed and predicted have proven important in the diagnosis of insight into the psychological processes underlying human learning in different contexts (Ritter and Schooler, 2002).

The present research also set an innovative new criterion for a truly enjoyable accessible computer game. Here, two well-known sets of learning curves (power law and exponential law, or the third, the linear function) were considered. The exponential law tends not be found in work contexts, particularly work that involves heavy-overloads. However, it is suggested here this law may be found to apply in the context of truly enjoyable games, where players are highly motivated. If so, overloads in a game context may provide stimulation but degrade game performance (Hung and Adams, 2010). This is clearly an important consideration for interactive game design, since players will want both an initially attractive game and a game that maintains or even develops their further interest that will not decrease with practice. Furthermore, this issue of exponential learning curves was heavily debated by Heathcote, Brown and Mewhort (2000) in their published paper, "The Power Law repealed: The case for an Exponential Law of Practice." This is interesting, since for the first time a case of the Exponential Law applying rather than the expected traditional Power Law in computer games conditions were found.

Whilst there is considerable work on the human learning curve in psychology, there, as yet, has been little work on the implications of the learning curve for interactive design and the game player's (Erev and Roth, 1998; Gee, 2005), for accessible game design (Archambault and Gaudy et al., 2008), or for sound-only computer games (Hung and Adams, 2010), that is really worth considering in the context of accessible computer games. Perhaps a different function law rather than the two expected (power and exponential) laws could be shown in the context of computer games due individual differences, motivation or other circumstances? If so, we have arrived at a testable explanation of the difference between exponential versus power learning laws. If this is correct, power functions will be found when participants are not highly motivated as is often found in a typical laboratory experiment, whilst exponential functions are more likely to be seen for more highly motivated participants such as are found in an enjoyable game. On this basis, an exponential function may indicate well motivated participants and, therefore, a well designed game.

5.3.5.3 Cognitive Overload

The second choice of diagnostic is the concept of cognitive overload, often induced by the introduction of a secondary task. Where such a dual task requirement is introduced, human performance can sometimes be severely impaired (Parshler, 1998). However, it is not widely appreciated that the absence of an effect can be equally informative. In many cases, a secondary task will not impair performance. For example, the lack of dual task effects in shadowing tasks has been used to propose the existence of modular cognitive processes (such as privileged loops) that can function relatively autonomously (McLeod and Posner, 1984). Strikingly, the lack of dual tasks effects for short-term memory tasks gave impetus to the development of the important concept of working memory (Baddeley and Hitch, 1974; Baddeley, 2001). Of direct relevance to this research, increasing practice can mitigate dual task, cognitive overload effects (Tulving, 1981). Thus the combination of practice level and secondary task addition, as explored here, might be expected to introduce valuable interactions that can be used to understand the psychology of the users. As yet, there are few studies of cognitive overload in interactive game playing (Ang, Zaphiris and Mahmoud, 2007). According to Ang, Zaphiris and Mahmoud (2006, 2007), cognitive overload may entirely produce different effects in game playing to users when compared to more typical work environments (Ang, Zaphiris and Mahmoud, 2007).

Chapter 6

Results

6.1 Introduction

This chapter will examine the participants' performance, motivation learning, and experience by observing the nature of their learning curves whilst game playing. This chapter will also evaluate the impact of cognitive overload, if any, created through the provision of a secondary task. Simple experimental design was used, where the factors of practice and overload were treated as within-subject variables and analysed by analysis of variance ANOVA. A total of eight different experiments are reported in this chapter that investigated the feasibility of these two diagnostics (learning curve and overload) in an experimental paradigm. The experimental paradigm is summarized, as follows:

The First and Second Experiments used a conceptually based design, in which an existing sound-only game, namely the Drive game was chosen to match the concept of an enjoyable sound-only game.

Experiment Three and Four emphasized an experience-based approach in which a new sound-only game, namely the Totally Lost 1 game was developed based on the participants' experiences and feedback from the first game. The design of the Totally Lost 1 game was based on the consideration of ecological validity, by the choice of realistic and important functions, namely navigational and related cognitive skills (memory) in a realistic context. This provided further support for the third approach, which is the user-participative approach. The second game, the Totally Lost 2 game was developed based on participants self-report. Their suggestions were later converted to a set of question-based heuristics, namely the HUNGS heuristics.

Experiment Five was conducted with new volunteer sighted non-musician participants based on the Totally Lost 2 game. Since a questionnaire is an effective combined-approach to measure game contents (Fu, Su and Yu, 2009) and was proven capable to diagnose the accessibility of interactive computer games, participants' feedback were initially accumulated in questionnaire form, the latter generated into useful design data.

Experiment Six investigated the learning curve of twenty-four new participants (consist of eight sighted people, eight absolute pitch musicians and eight blind people), and measuring the acceptability and enjoyability level of a newly developed game, namely the Totally Lost 3 game. Unfortunately, some participants' results were particularly noisy. Non-significant results were showed, indicating their results could not suitably fit any obvious learning functions. The results from this experiment were further analyzed in Experiment Eight.

A more competitive approach was used in Experiment Seven. The four participants who have played the Totally Lost 2 game, once again, were asked to play the Totally Lost 3 game together in a laboratory via a computer network. Additionally, two new professional blind participants were recruited. This experiment explores the change of learning curves based on our blind participants' game performance when competing against each other in groups (group competition). The three highest game scorers in this experiment will receive a GBP 10 note as reward by mean of lottery.

Experiment eight investigates two research hypotheses. First, analyzing detailed learning curves from our participants based on a significant number of trials (thirty trials) were used to explain non-significant results from the participants' data found in Experiment Six and Seven. Second, the participants' learning curves were explored based on individual differences and powerful motivation (reward system). The top scorer from this experiment will receive a significant financial reward.

6.2 Experiment One

Experiment one investigated the learning curve and the possible effects of a secondary counting task for five volunteer participants when playing the Drive game over a significantly large number of attempts (n = 100). At least three important questions will be asked in this experiment, as follows. First, would typical laboratory results be found in the very different context of the sound-only interactive game? Second, would the shape of the learning curve support one set of explanations over another? Third, would the nature of any cognitive overload effect clarify the role of cognitive overload in game playing?

6.2.1 Methods

Five volunteer sighted participants were recruited to participate in this experiment. Each of them played the game individually, with rest breaks on request between games. The games were spread over three days. The five participants played the game for 100 times ($n = 100$). They were young adults, age of 18 to 29, were volunteers and were not paid for participation. The participants consist of three males and two females. They have substantial computer game experiences, and play computer games quite often. Before the experiment session, they were asked to test the game for five times, to understand the game in depth.

6.2.2 Results and Discussion

The first experiment explores the initial learning curve from the five participants. The results were based on analysis of variance (ANOVA) using the SPSS application to explore the nature of their learning curves. To explore the learning curves with prolonged game playing practice for 100 times, linear regression and non-linear curve fitting analyses were conducted on (a) the average scores per person over a block of ten game attempts (b) the average scores per person per trial ($n=100$). This will also explore the influence of simple curve smoothing. The results from SPSS clearly shows that performance ($R = .952$) improves significantly with practice, and have showed statistically significant results ($F = 78.16$, $df = 1, 8$, $p < 0.001$) from this group of participants.

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	VAR00002[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: VAR00003

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.952[a]	.907	.896	.97851

a. Predictors: (Constant), VAR00002

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	74.840	1	74.840	78.163	.000[a]
	Residual	7.660	8	.957		
	Total	82.500	9			

a. Predictors: (Constant), VAR00002

b. Dependent Variable: VAR00003

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6.590	1.402		-4.700	.002
	VAR00002	1.68E-005	.000	.952	8.841	.000

a. Dependent Variable: VAR00003

table 6.1 Experiment One: Descriptive Statistics

A striking finding is that a power law works well across all analyses, including; the average scores per person per ten trial, the average scores per person per trial, log transformations of those scores (four analyses) and the corresponding data for each participant taken individually (five analyses. The nine analyses that tested for the power function yielded seven results where the significance of fit was $p < 0.0001$, one with $p < 0.012$ and one with $p < 0.002$. These last two results were based on two sets of individual scores, possibly reflecting a greater level of variance in these data, though all five participants displayed a significant power law fit. Looking at all nine instances of curve fitting, the power function produced a better fit than the exponential function in eight out of nine cases (Wilcoxon $z = 3.724$, $p < 0.0001$). The only case where it did not was found with the data of one participant whose data were particularly noisy.

However, it is particularly notable that the power law still applied when the data for blocks of ten game attempts were transformed by a logarithmic (base 10) function, when we would have expected a purely linear function. This result implies a complex but very lawful function. As shown in figure one below, the fit of the power function was particularly close, with value of R2 equal to 0.999, such that the power function explains 99.9 per cent of the variance in these data, with a massive associated F value of 7256.718 (df; 1,8) p <0.0001). The group and individual data analyses are set out in the Data Appendix.

There are six important features of these results. First, they unequivocally support power functions over exponential functions, contrasting with the results of a major survey that favoured exponential functions (Heathcote, Brown and Mewhort, 2000). There are several sets of explanations. First, the Drive game might not be fun enough to motivate the participants to reach a stage where their data could fit the exponential function. Second, the exponential function may not be visible in the context of sound-only computer games.

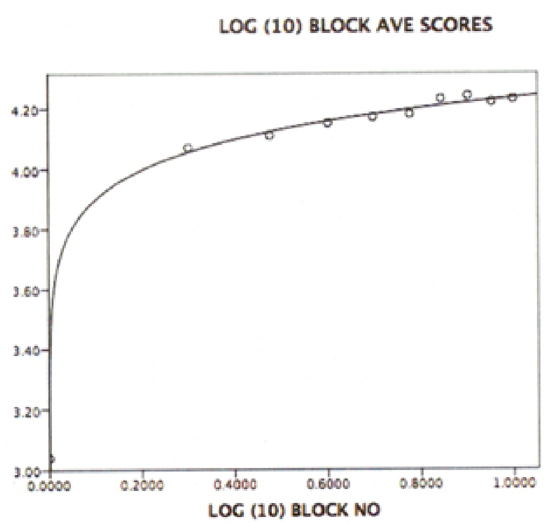


figure 6.1 Experiment One: Log (10) Block Averages Scores

Exponential functions often produced significant fits to the participants' data, but typically less so than the power functions. Second, this superiority applies both to the averaged data and to the data for individual participants and so is not an artefact of the averaging process (Heathcote, Brown and Mewhort, 2000). Third, reviewing current research indicates that a power function is associated with an underlying learning rate that slows over time, unlike the exponential curve that is consistent with a constant learning rate (Heathcote, Brown and Mewhort, 2000; Friberg and Gardenfors, 2004). If so, it could reflect different levels of user motivation and interest with the game. Fourth, the present results are consistent with the expectations of a small group of theories, including ACT-R, SOAR and Simplex Two. Fifth, when the data are subjected to a log (base 10) transformation, an interesting new result emerges. When considering averaged data per trial (n = 100), the linear function fit increased, as would be expected, from R2 = 0.679 to R2 = 0.848, whilst the power function fit decreased, again as expected, from R2 = 0.848 to R2 = 0.473. However, when using averaged data based on blocks of ten trials (N = 10), the linear fit did not increase (R2 decreased from 0.860 to 0.670) whilst the power function fit increased from R2 = 0.966 to R2 = 0.999. As can be seen from figure one, the fit of the power function when the data (blocks of ten game attempts) are subjected to a log transformation is almost perfect, with 99.9 per cent of the variance explained.

This result is novel and, if not an artifact implies a log power law may also apply. However, the practical importance of this result lies in the potential it offers to predict players' performance with significant accuracy. Sixth, all of these results have been obtained in the new context of interactive game performance with a sound-only game.

6.3 Experiment Two

Experiment two further investigates the learning curve with the introduction of secondary tasks (dual-tasks). The outcome of this experiment will provide a better understanding of the influence of cognitive overload on game performance of the Drive game. Two secondary tasks were introduced; the traditional auditory counting backward task and visual-colored ball matching task. The purpose of this experiment is to provide a distinction between the two overload tasks, analyzing which overload is more powerful that could impact game performance. This is clearly an important consideration to understand different overload effects and consider implementing different overload effects into the design of new sound-only games to hopefully, contribute at producing significant satisfaction to the game play.

6.3.1 Methods

Six new volunteers were given initial training on the Drive game. They were young adults, age of 18 to 29, were volunteers and were not paid for participation. The participants consist of four males and two females. They have strong computer games background and play computer games regularly. Then, they were asked to complete three blocks of ten game attempts per block. A traditional before and after design was used to evaluate the impact of a secondary task. The first and last blocks of ten game attempts were without a secondary task. The second block used a secondary task. Two participants were given an auditory task. Two participants were given a visual task. Two participants were given both an auditory and visual task concurrently. The auditory secondary task comprised the traditional backward counting task, starting with 100 and counting down in threes (100, 97, 94, till 0) and repeat from 100 again.

The visual secondary task requires the participant to play the sound-only game whilst matching the colour simultaneously based on three different sheets of papers. The first paper contained 12 random coloured balls. There are numbering on each balls (i.e. 1, 2, 3 ... 12). The second paper contained 50 different questions, mainly asking the participants to agree / not agree on the colour of the ball (i.e. is the colour of ball-12 blue?). The third paper is an answer sheet, containing all answers for the 50 questions. Here are the procedures: the participants need to look at the second paper (question sheet), read the question and look at the first paper. If they agree, they need to say nod their head (shake their head if no) and look at paper 3 for the correct answer. Then, they need to proceed to the next question in paper two.

6.3.2 Results and Discussion

Evaluating the average scores per person per block, the addition of secondary tasks did not reduced the participants game performance . Describing performance in terms of non-secondary performance minus the related average of non secondary tasks over the ten game attempts, produced a non-significant trend over attempts (F = 0.81, N. S.), a non-significant interaction between the number of attempts and type of secondary task. Neither overload effects could negatively impact game performance . Perhaps the overloads are too simple to produce an impact to performance, or the secondary task has become an extra stimulation here? However, there is a massive difference between the impacts produced by the two different secondary tasks (F = 1330.51, p <0.0001). The dual secondary task was much more influential than either single secondary task, perhaps reflecting the limitation of cognitive capacity. The auditory and visual secondary tasks did not differ from each other, even though this was a sound-only game. This suggests a general overload effect (executive function), rather than a specific perceptual or sensory effect. In addition, the programmer of the Drive game mentioned that the game is originally invented for blind children and not for adults. Clearly, this require further clarification, but with a different game aiming for adult participants.

6.4 Experiment Three

Experiment three investigated the learning curve and the effects of a secondary counting task for different volunteers (two groups of participants) when playing a newly designed sound-only game, namely the Totally Lost 1 game, over a significant number of attempts, five times as practicing and another 200 times (n = 205) for group a. Participants from group b only played the game for 135 times (n = 135) In this experiment, the participants were asked to perform auditory counting task when playing the game. The auditory secondary task refers to counting backwards by one from 100 to zero. An auditory secondary task was chosen rather than visual task because visually impaired players could not perceive visual cues. Thus we could not test the feasibility of sound-only games for learning and the impact of dual task effects for visually impaired people. Overall, this experiment is helpful to evaluate the accessibility and enjoyability of the Totally Lost games, if possible, truly enjoyable games could mitigate the overload effects.

6.4.1 Methods

Eight new volunteer participants were asked to blind-fold themselves when participating in this experiment. The participants have to blind-fold themselves since the game contained important two visual cues (the mouse cursor and the game scores). As a result, the sighted participants who participated in this experiment will still rely on these visual cues to play the game and so, could not contribute to evaluate the accessibility of this game . They were divided into two groups (group a, and b), based upon the number of trials attempted in phase five - participants from the first group played the game for twenty times, and forty times for second group. They were young adults, age of 18 to 29, were volunteers and were not paid for participation. The participants consist of four males and four females. They are computer literate who play computer games on a regular basis. Before starting, the participants practice a simple secondary task consisting of backward counting (starting with 100 and going back by ones, backwards from 100 to zero for three times). We started off this experiment with a simple counting task to understand the threshold level of cognitive overload of our players. They might find counting backwards a difficult task when handling game playing. If so, a simpler counting task will be introduced in the next experiment. The participants each played individually, starting with five practice attempts with the game designed to familiarize them with its basic requirements. The main experiment was divided into eight phases.

1) In phase one, each participant from the two groups played the game for 100 attempts. They were asked first to play the game for five times to understand the game play. The aim of this phase is to measure the participant's learning curve.
2) In phase two, the participant played the auditory game for ten times without a secondary task. This is a baseline measure.
3) In phase three, the participant played ten games whilst also doing a secondary task.
4) In phase four the participant again played the auditory game for ten times without a secondary task. This is a second baseline measure.
5) In phase five, the participant played the auditory game for forty times (group one) or twenty trials (group two) without a secondary task, to add to participant game learning.
6) In phase six, the participant played the auditory game for ten times without a secondary task.
7) In phase seven, the participant played the game for ten times whilst doing the secondary task.
8) In phase eight, the participant played the game for the next ten times without a secondary task.

For phase one (n = 100), their game scores were recorded individually and analyzed with SPSS, to understand their learning curve of the game. Since the Totally Lost game is a new sound-only game, our players learning curve is important to measure and evaluate the feasibility of the game. If the game is feasible by mean is accessible and enjoyable, then the next few experiments will be based on this game. Else, a different game will be produced (contain similar contents of the Totally Lost game). The game scores in phase three and four can be compared with adjacent phases to estimate the size of any cognitive overload.

6.4.2 Results and Discussion

The first analysis looked at the eight participants' learning curve (see figure 6.2), followed by the second analysis, analyzing the initial influence of any cognitive overload created by the first encounter with the additional, secondary counting task.

Phase one explores the learning curves of the participants to provide a consistent capture of the Totally Lost game. Clearly, performance improved significantly with practice, but was impaired by the introduction of cognitive overload in phases three and seven. The main effect of phases was found to be significant by two-way analysis of variance (SPSS linear model) with repeated measures, with F = 3.6 (df 7, 42), p <0.005, two tailed). In addition, the interaction between phases and groups was also significant (F = 2.99, df 7, 42, P <0.012, two tailed). This is due to the higher scoring, or more practiced group showing clearer overload effect.

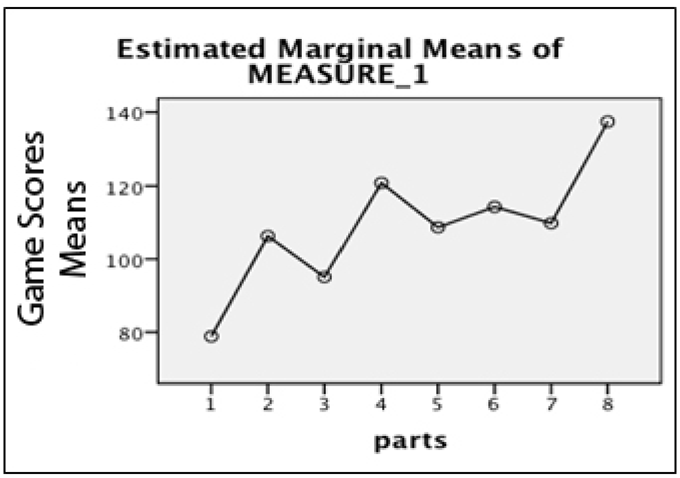


figure 6.2 Experiment Three: The mean measure of Eight Participants and Game Scores, in Phase One

The result of the eight participants for phase three (with the counting task) were compared with the average of phase two and four (baseline), as shown in the table below. Then the result of our eight participants for phase seven (with the counting task) were compared with the average of phase six and eight (baseline). This is also shown in the table below. The comparisons were based on the SPSS procedure for the Wilcoxon test. In both cases, performance was impaired significantly by the cognitive overload introduced by the secondary counting task. At least one conclusion has been crafted, that is, an enjoyable computer game with slight overloads should balance players game performance and their experience appropriately. The result was shown clearly in figure 6.2. Generally, only less pleasurable computer game reduces the attractiveness of the game (Scollan, 2007) and could impair performance although the overload effects are not obvious. In addition, there was some suggestion that the size of the impairment reduced with practice but this contrast (for six out of eight participants) was not itself significant.

Phase 2	**Phase 3**	**Phase 4**	**Averages (2 and 3)**	**Wilcoxon**	**P Value**
17.48	15.55	20.14	19.06	Z=2.52	$< .012$
Phase 6	**Phase 7**	**Phase 8**	**Averages (6 and 8)**	**Wilcoxon**	**P Value**
17.76	17.33	22.11	19.94	Z=2.24	$< .025$

table 6.3 Experiment Three: Descriptive Statistics (please refer to section 6.4.1 Methods for details

Perhaps playing the same game repeatedly could generate some fatigue or boredom effect. Secondly, the design of the Totally Lost 1 game may be poor and decrease the player's learning experience (Sicart, 2009). As a result, the player's could not focus the game play and score higher. If so, the Totally Lost 1 game should be calibrated to enhance participant's experience. Average scores for phase two and three, and phase six and eight are shown in the table above.

6.5 Experiment Four

Experiment Four involved further investigated of the game design of the Totally Lost 1 game and the effects of cognitive overload. According to Walker (2003), employing different groups of participants is essential to evaluate the accessibility of the computer game. Therefore, in this experiment, eight new sighted non-musician volunteer participants were recruited. This experiment is important to analyze the feasibility of the Totally Lost 1 game, assuming that the cognitive overload effects are either too strong or weak (in the previous experiments) and negatively impair the participants' game performance, or the design of the game is not acceptable to them. If the focus is on the cognitive overload effects, due to the inefficiency of the counting task or tasks in the game (content) is too hard, then the level of complexity of the secondary task or the task in game should be reduced. On the other hand, if the participants' game performance decreases due to an unattractive games design, the Totally Lost 1 game should be re-designed since the motivation of the research is to design an accessible and enjoyable game. As a part of this research, any games that decrease users' motivation and performance even if they try playing the game with complex skills (complex sequence output) should be re-designed.

6.5.1 Methods

Eight new sighted non-musicians were recruited for this experiment. They were young adults, age of 18 to 29, were volunteers and were not paid for participation. The participants consist of four males and four females. They were familiar with computer games, and often played computer games. The intrinsic content of the secondary counting task in this experiment has been changed to one in which the participants had to count backwards in threes (100, 97, 94...0) in order to see if this would make the counting task more difficult and the effect bigger. In fact, this approach is important to estimate the participant's cognitive capacity and the game performance. On the other hand, if the result of this experiment indicates that this overload effect could increase the challenge of the game or motivate the participants to play the game more effectively, then similar overload effects should be considered in the games design. The participants practiced counting backwards in threes for three times before starting this experiment. The participants were asked to participate in four different phases of this experiment. They have to play the game for a total of 135 times (n = 135). First, the participants were asked to practice the same sound-only game for five times. The duration of every game session is one minute.

1. In the first phase of the main section of the experiment, they were asked to play the game for 100 times to build up their experience of the game.
2. In phase two, they were asked to play the game for ten times without a secondary task.
3. In phase three, they played the game for ten times whilst performing the counting task.
4. In phase four, they played the game for ten times without a secondary task.

Their game scores were recorded individually.

6.5.2 Results and Discussion

As for previous experiments, the influence of the second task was evaluated using the Wilcoxon test on SPSS. This time, the impairment due to the second task was not quite big enough to be statistically significant ($Z = 1.82$, $p < 0.069$), though if the three analyses were combined in a meta-analysis, the effect was comfortably significant ($z = 2.70$, $p < 0.001$). In fact, some participants did not perform the counting backwards task properly. They were counting backwards very slowly at a stage where they almost skipped the entire counting process. Few participants were counting slowly too, though they set their focus more to concentrate on the game play, rather than the counting task. This is not surprising as a person could place greater overload to their working memory if concentrating separate tasks across one sensory channel.

Phase 2	**Phase 3**	**Phase 4**	**Averages (2 and 3)**	**Wilcoxon**	**P Value**
18.08	14.11	20.31	19.19	Z=1.87	< .069

table 6.4 Experiment Four: Descriptive Statistics (please refer to section 6.5.1 Methods for details

PART	**Mean**	**Std. Deviation**	**Count**
PART1	16.8925	7.28984	8
PART2	20.3125	10.27347	8
PART3	15.3375	7.05285	8
PART4	22.2875	10.49890	8

table 6.5 Experiment Four: The Eight Participants Game Score and Mean Measurements from Phase One to Four

Turning to practice effects, repeated measures analysis of variance (SPSS linear model), again demonstrated a clear effect of practice that was not obscured by overload effects ($F = 5.27$, df 3,21, $p < 0.007$).

6.6 Experiment Five

Experiment five was conducted based on the Totally Lost 2 game. Totally Lost 2 was developed based on a thorough evaluation obtained from the participant's self-report of the Totally Lost game. It has more game maps. This experiment was conducted with two separate groups of participants (professional musicians and sighted non-musicians). Non-musicians were defined here as people who never used a musical instrument before. The objective of this experiment is to compare musicians and non-musicians game performance (game score) when playing the games. This experiment also explores three feasible hypotheses. First, the Totally Lost 2 game is playable by any computer users. Second, the musicians might produce higher game scores compared to non-musicians since there is the possibility that they have stronger sound perceptual skills. The musicians' game scores could also motivate sighted people to learn better. Third, professional musicians, especially those who have wider knowledge of computer games may be able to evaluate and discuss the acceptability of the game better than non-musicians.

6.6.1 Methods

Thirteen sighted adult participants of age range from 18 to 30 were recruited to participate in this experiment. They volunteered themselves to participate in this experiment and were not paid for participation. Nine of them are professional musicians (all female musician participants), and the other four are sighted non-musicians (the participants consists of three males, and a female). All the thirteen participants were asked to participate in the sound-based tutorial session before starting the game. Then, they were asked to practice the game for three trials to understand the game play. Their game scores were recorded individually.

6.6.2 Results and Discussion

This experiment is important to understand the differences between musicians and non-musicians game performance. As reported by Nikjeh (2006) in one of his studies, no visible significant results could be found between two such groups of participants in voice pitch matching. This increases the interest of this experiment, as a matter of fact, since the results from this experiment showed clearly significant results ($F = 11.00$, df 1, 11, $p < 0.008$), showing that the professional musicians do perform better than non-musicians. Perhaps the experiments in the real-world and computer games context do show significant differences, or the study conducted by Nikjeh did not recruit real professional musicians?

Participants	Mean	Std. Deviation	Count
Musicians	23.22	5.74	9
Non-Musicians	11.50	6.24	4

table 6.6 Experiment Five: Comparing Musicians and Non-Musicians Performance based on the Mean and Std, Deviation of their Game Scores

This experiment also suggests similar results to the work reported by Tierney, Bergeson and Pisony (2009) that professional musicians could outperform non-musicians in most auditory memory tasks. Anyway, this is not surprising since musicians do have stronger left-temporal lobe functions than non-musicians (Schlaugh, Janckle, Huang, Steinmetz, 1995), especially those who study music at early age (Pantev, Oostenveld, Engelien, Ross, Roberts and Hoke, 1998) or professional musicians who received intensive music practice and training (Gaser and Schlaug, 2003).

The participants were grouped into two; musicians and non-musicians. The two sets of scores are analyzed with one-way analysis of variance on SPSS.

Participants	Mean	Std. Deviation	Count
Musicians	5.56	2.13	9
Non-Musicians	6.50	2.65	4

table 6.7 Experiment Five: Comparing the Participants Enjoyability Level based on their suggestion from the Questionnaire - Question 11; see Appendix 9.13

Averagely, the musicians rated the enjoyability level of the Totally Lost 2 game slightly lower than non-musicians ($F = 0.475$, df 1, 11, $p < 0.008$). This is shown in the table above. In fact, the Totally Lost 2 game is considered as a serious game that requires more memory capacity than other games. Apart from memorizing the seven different keywords as the participants' progresses through the game, they have to memorize each and every sound item. This is not a simple task, especially for people with limited memory capacity. The game is too demanding as there were approximately twenty different types of sound the player must memorize. Given the fact that all our sighted non-musician participants are expert computer game players when compared with the musicians, it is not surprising that they could enjoy the game better, particularly at responding better to sound information (Musacchia, Sam, Skoe, and Kraus, 2007) or understand and memorize them properly (Chase and Simon, 1973).

In other words, professional musicians do have greater accuracy in sound perception (Musacchia, Sams, Skoe and Kraus, 2007). This is why they could score better than non-musicians (see Table 6.6). The musicians have stronger working memory than non-musicians when dealing with complex auditory perceptual tasks (Alexandra, Erika et al., 2009), but their motivation is less based on what they suggest in the questionnaire (see Appendix 9.13). Two possible reasons were crafted based on these findings. First, professional musicians here seldom play computer games so they could not call upon any generic expertise in games playing. Second, all the professional musicians here are female. According to Steiner, Kickmeier-Rust and Albert (2009), females generally have lower preference for violent or tension computer games. This may subsequently increase their adrenaline boost compared to sighted non-musicians. As a result, they will keep losing the game. So, their motivation fades away quicker. Usually, expert game players (non-musicians) are highly competitive people. They insist that winning a game is important for them. Such a competitive mind will help them to make the game play more challenging.

There are two important suggestions reported by the musicians after playing the Totally Lost 2 game. First, they treated this game as fun, exciting and very special whereby the player could play the game with only sound cues. Second, the game could be overly challenging where it require too much concentration from them. This is probably a negative aspect for a computer game since most players will feel tired easily if they could not understand the game after many trials. Musicians also have larger auditory cortex than sighted non-musicians (Pantev and Oostenveld et al., 1998). This is why musicians could concentrate better in sound-only games. More importantly, our musicians here have the absolute pitch ability. Perhaps the ability could help the musician to perform well without enjoy that particular auditory task? At the very least, as reported by Schlang and Janckle et al. (1995), musicians with the absolute pitch ability could outperform those without in advanced auditory skills. Absolute pitch refers to "the ability to name a pitch (in reference to the musical scale, generally by letter name) or to produce a pitch designated by name without recourse to any external source or standard ... individuals with this ability possess an internal standard pitch in long term memory" (Randel, 2003, p. 2). Overall, the professional musicians and sighted non-musicians suggest that the game is enjoyable, but difficult or sometimes even impossible to be played. They described the importance of the complex game elements and important storyline, making the game very interactive.

6.7 Experiment Six

The Totally Lost 3 game was designed based upon its existing version, the Totally Lost 2 game. The modification of the Totally Lost 2 game was proposed by our participants after playing it (see Experiment Five). The initial concept of the Totally Lost game is to use a computer mouse as navigation. So, as a part of this experiment, the feasible option of this game controller was evaluated. This experiment will also consider some methodological questions. First, could blind participants use the computer mouse to play the game if they are only familiar with keyboard in their work context? Second, will the computer mouse increase the complexity of the game whilst reducing the enjoyability, or vice versa? A new application, namely the mouse tutorial has been designed and developed for this purpose, and proposed for use by the blind participants before participating in this experiment. In the tutorial, the blind users were asked to navigate around the tutorial-world with a computer mouse, and using the two mouse buttons for different functions. Using the application should educate them to work with a computer mouse if the application is designed properly.

This experiment will also provide a thorough analysis of the participants' game performance. Specifically, the participants recruited here are sighted non-musicians, professional musicians with the absolute pitch ability and totally blind people. Although the participants will play Totally Lost 3 individually, but it is intended that they will feel motivated to learn, when they were told that their game scores will be compared with other participants' scores. Perhaps this is not a surprising matter, as reported by Sanchez, Baloian and Hassler (2004), blind people are competitive than sighted users, particularly when they are competing games playing with sighted people. They will feel more competitive if they know their game scores will be used for comparison purposes. They will feel motivated if their scores will be used to compare against sighted peoples' scores.

This experiment will also measure the enjoyability of the Totally Lost 3 game in a novel way, where participants' data (game performance) were collected for further analysis on SPSS. Their game scores will also be matched against different learning curves. Our understanding is that a truly enjoyable game is a game that never slows down learning. It keeps the user motivated and stimulated over a number of trials. If so, an exponential function could be used to explain truly enjoyable computer games. The participants were asked to fill in the questionnaire after every game session. Their game scores were recorded individually.

6.7.1 Methods

Twenty-four volunteer participants (two musicians from this group have previously participated Experiment Five) were recruited to participate in this experiment. They voluntarily participate in this experiment, and were not paid for participation. They were consisting of eight blind people (the blind people consist of six males and two females), eight absolute-pitch musicians (all the musicians are females) and eight non-musicians (the sighted non-musicians consist of six males and two females). All the blind participants' here are total blind. Their blindness was determined by the Malaysian Association for the Blind. Our vision impaired participants could only sense the presence of light but nothing else. The second group of participants is musicians who possessed the absolute pitch ability. Their ability is determined by the Yamaha Music Association. They have a greater sense of auditory perception than most people. Since the blind participants have no clue about using a computer mouse, they were asked to participate two times in the mouse tutorial application tailored-made for them before start playing the Totally Lost 3 game. All the participants were asked to answer all the questions on the questionnaire at the end of the experiment session. Finally, the participants were asked to play the game for only six trials. They were not asked to practice the game before starting the experiment. Their game scores were recorded individually by the author. The experiment session took place in Kuala Lumpur, Malaysia.

6.7.2 Results and Discussion

The results analyzed by SPSS showed that the diagnostic results apply in this context, formed a novel result but in surprising way. Both the power and the exponential laws apply to this sound-only games. Interestingly, some participants' data could fit the linear function, too. So, in summary, three learning functions were found from the participants' game results. Also, cognitive overload does occur, but accompanied with an increase of satisfaction. So, different users' game performance generated different learning curves in a surprising way, and will be discussed in-depth later in this section.

The twenty-four participants' data were grouped into three different groups; Group 1 consists of absolute pitch musicians, Group 2 consists of sighted participants, and Group 3 consists of blind participants. Each group contains eight participants. Every participant's game performance is measured over six game trials for the Totally Lost 3 game, as showed in Appendix 9.8.

A further presentation of the participants' average game scores are shown in the descriptive table in Appendix 9.8. Noticeably, the blind participant group scored the highest total average score compared to the other two groups. This is not surprising since blind people are usually more sensitive with sound perception compared to other people. Their auditory perceptual skills will not improve due to their blindness, but they will improve their listening skills by training themselves to be more careful with sound selection (Jacoby and Youngson, 2004).

Surprisingly, absolute pitch musicians who started with higher performance (positive superiority or higher intercept) lost their performance advantage over time although they only played the game for six trials. Similar to Musacchia and Sam et al. (2007) findings, musicians usually display superior auditory processing skills in any sound-related contexts , and so, they could score highest in the first few trials, however improvements in their game scores slow down with time. Perhaps these musicians have strong perceptual skills but lack gaming skills compared to sighted people who could perform better and blind people who are highly motivated over interactive computer games with which they have not played before? At the very least, the musicians here agree that they are quite impatient sometimes, assuming that "they will try to learn something new quickly, but their learning slows down after mastering it". However, this also depends on the individual themselves since most musicians could change their mind about something quickly based on their current emotions and perceptions (Kippen, 1988). Alternatively, as expected, the reward system may have played an important role to motivate the participants to achieve higher game scores.

From the figure below (see Figure 6.3), obviously the group of blind players tends to show lower game performance in the first few trials compared to the other two groups. However, their performance increases, forming a steeper learning curve than the other groups of participants. This could be caused by one or more factors. First, they have not played any computer games before. They only use their computer for work purposes, so sound-only computer game is something new and intrinsically interesting for them. Therefore, it is not surprising that they started off with lower performance and end up higher since they need more time to learn compared to other players. Second, their learning curve rises gradually, reflecting their interest in the game. Again, this is not surprising since blind learners will be more interested in comparing their performance with other people, particularly sighted people. They will feel more motivated to show that they could adapt to activities performed by sighted people and experience it as a challenge (Sanchez, Baloian and Hassler, 2004).

This is a good explanation, explaining why the blind participants possess superior learning and higher motivation when playing the game.

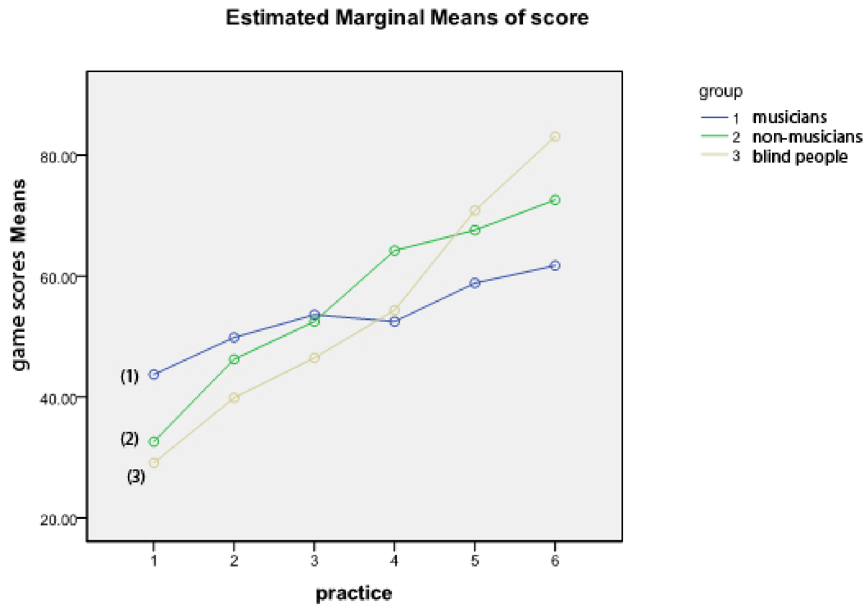


figure 6.3 Experiment Six: Comparisons of Game Performance between the Three Groups of Players

On the other hand, the sighted participants have performed very well. Although the Totally Lost 3 game is a sound-only game where the game could be played on by auditory cues, the sighted participants could perform and produce interesting results. This group of participants' game performance is moderate when compared to the other two groups of users. Interestingly, their results remained in the middle between the musicians and blind people. Initially, as expected, sighted people do not possess superiority in sound perception. Apparently, sighted people are more devoted to visual cues. So they could not easily outperform blind people in sound-only games.

This experiment compared sighted musicians (with absolute pitch) with blind people in term of their auditory perceptual and memory skills in the context of sound-only computer games, and has analyzed the absolute pitch musicians performance when dealing with sound only games. The results of this comparable study show that musicians with absolute pitch have performed better in the initial stage of testing, but their learning dissipated over time. Generally, the blind player group achieved highest overall game score. Overall, as expected, blind people require a lot of memory power for their daily activities (Schulze, 2001). They also have stronger auditory perception and performance and so, perform better than any sighted participants. Therefore, it is not surprising their game score could surpass other groups of users since they are training themselves everyday to perceive sound cues accurately.

The regression analysis in Appendix 9.9 tested the most significant curve based on the three groups of participants' game performance. The analysis revealed interesting results, separately based on the three groups of participants. Clearly, each group showed different shapes of learning curves. Individually, the musicians' game scores is quite linear ($F=53.68$, $df = 1, 4$, $p < 0.005$), however their learning curves show slight emphasis, positively correlated to the power regression ($F=55.90$, $df = 1, 4$, $p < 0.005$). On the other hand, sighted non-musicians' game performance supports the power function. The power function provides a clearly better fit than either the linear or exponential function, indicating very strong relationship with the power curve ($F=461.53$, $df = 1, 4$, $p < 0.001$). In contrast to the results from the two groups, the blind participants supports the exponential function ($F=337.85$, $df = 1, 4$, $p < 0.001$), providing a clear and better fit than both linear and power functions, though the linear function provides an intermediate level of fit.

This is a very important empirical finding, such that it demonstrates that the shape of the learning curve changes with circumstances. As expected, the blind participants (as rated by them in the questionnaire and discussion sessions in Chapter Seven) really do enjoy the game (Totally Lost) to an extent where they feel the game is extremely challenging whereby motivating them to play and perform well throughout the six trials. More interestingly, the blind participants suggest that they only like specific games, and not all types of games. This may be due to individual differences? In this case, game designers should place more attention when designing interesting and enjoyable games for this group of players . At least, there are two reasons of why they really enjoyed playing this game. First, this is the game genre they really wish to play (through the provision of the questionnaire, Question 8; see Appendix 9.13, and verbally between the author and the blind participants) . Second, they like playing the sound-only game not only because they have not played computer games before, but the game provide relatively interesting features that could attract them to play. Such a game provides helpful features that could contribute to their daily activities. Musicians whose game score showed they performed very well at the beginning, diminished in the second half. One reason could be the game content, where it did not motivate them to score better after the six trials due to different circumstances. Overall, they assume that they have lack of computer knowledge and skills. Perhaps they will feel motivated again if the computer game is accompanied by some musical instruments, such as using a piano or violin as controller? Finally and understandably, the sighted participants found the game is interesting since playing sound-only computer game is something new that they have never tried before. The idea of the sound-only game is relatively novel such that they could play the game with a blank screen. However, as explained in their questionnaires, they still prefer visual cues over sound-only when playing computer games no matter how much fun the game might be, since visual cues are important for them. As explained by Fisher (1963), sighted people relied heavily on the presence of visual cues in their perception, particularly in the course of their development. Unless there are some extremely challenging activities that will motivate them seriously, they still prefer visual games. This could be one reason why sighted people prefer visually attractive 3D over traditional 2D video games.

Finally, the findings above suggest that it is not a simple choice between power functions or exponential functions since the shape of learning curve may vary, depending on the context.

6.8 Experiment Seven

Six blind participants were recruited to further evaluate the potential of the Totally Lost 3 game. Overall, few sighted participants who have participated Experiment Six have suggested the enjoyability of the game is just slightly above the average level of enjoyable. This could mean they were still unable to give up the remaining sparse visual cues of the game. For them, the remaining visual feedback (e.g. game scores, time remaining, etc.) are still essential in order to play the game more effectively. One question here is if this notion implies that the Totally Lost 3 game has not reaches to the standard of truly enjoyable or is there still some remaining game features not entirely applied in the game so the players have not achieved their greatest enjoyability?

The objective of this experiment is important, to test one new game aspect related to game performance, namely competition. Indeed, competition is important in computer games. Yet, competition and performance have been studied little in computer games (Habgood and Overmars, 2006). Anyway, to test one of these research hypotheses, we have decided to explore further the concept of competition in the context of enjoyable computer games and human performance. If any participants could achieve the exponential function rather than the power law in this experiment, then a simple explanation could be crafted; as predicted by the research hypothesis, i.e. that group competition could motivate the game player and increase their game performance. Alternatively, competition may also induce stress to the players, as predicted by Stanley and Burrows (1987) and Littlefield and Sellnow (1992), subsequently reducing motivation and performance over time (Federal Aviation Administration, 2008).

6.8.1 Methods

A total of six blind participants volunteered themselves and not getting paid to participate in this experiment (four males and two females). They were adults, aged of 18 to 50. They were asked to play the Totally Lost 3 game, the same game that was tested in Experiment Six. The three male participants from this experiment have participated Experiment Six approximately six months ago, so they are familiar with the game. They were categorized in Group One: Individual in this experiment (see Appendix 9.10). The design is similar to the experimental procedure of Experiment Six, except that all the six participants have to play the game together, for six trials. The duration of every game attempt is two minutes. All participants in this experiment were asked to practice the game again, individually for two times before the experiment starts. They were asked to listen to the in-game tutorial session again, so they could be sure that they understood the game play. The participants were asked to fill in the questionnaire after completing the games. The participants were told (before the experiment starts) that the winner who completes the game with highest total game score will receive a ten pound note by mean of a reward. Their game scores will be recorded individually for further analysis.

The purpose of this research is to examine the efficacy of practice and the differences of playing sound-only games individually and competition. If the new participants game score is higher in competition mode, than participants who played the game individually, then competition is important for sound-only games. This feature has not before been analyzed in the context of sound-only games. The participants' game scores will be analyzed in SPSS (chi-squared analyses).

6.8.2 Results and Discussion

The results are produced by the SPSS 18. The full analysis for this experiment is found in Appendix 9.7 and 9.10.

The participants' game scores were added and placed into three different groups. The first group is based on the game scores of the three blind participants from Experiment Six. They first played the game approximately six months ago. This group was treated as a virtual group with which their scores were produced when playing the game individually. We named the participants as P1, P2 and P3 on SPSS (see Appendix 9.7). The second group is based on the three same participants' (P4, P5 and P6) new game scores collected for this experiment. The participants from this group generates the practice and group working effect since they have practiced the game in the past six months, and are now playing the game by competing with other three participants (P7, P8 and P9) in the third group.

All the participants' game scores were added up based on their own group. In summary, the first group consists of three participants (namely the P1, P2 and P3). Group two consist of three same participants as the first group, but they have participated Experiment Five (namely the P4, P5 and P6). The third group consists of three new blind participants (namely the P7, P8 and P9) who have not played the Totally Lost 3 game before. So, only group two and group three participants participated for the competition. The three participants from group one played the game individually.

Three tests have been performed in this experiment. Similarly, the tests deal with comparison of game scores between the three different groups of participants. The game scores of group one and two (phase one), followed by the scores of group two and three (phase two), and finally group one and three (phase three).

The result of phase one demonstrates the influence of both factors and was shown statically significant (61.46, df = 2, p <0.001). This result is promising but not surprising, as expected, performance improves overtime, based on practices and experiences. What are surprising are the apparent results showed in the third phase, showing that the three new participants (who have never played the game before, and now competing with other old participants in groups) game score could beat the three old participants' score (who played the game individually). The SPSS analysis for the third phase showed statistical significant results (F = 18.49, df = 2, p <0.001). Perhaps the influence of competition (or competing in groups) and reward (e.g. money) could trigger our blind participants' performance. Finally, in phase two, we could understand that experienced player will usually win most of the competitions when competing with new players who have not experienced the game before (F = 13.70, df = 2, p <0.001).

The results from the questionnaire indicated that blind participants could progress better in computer games if there were given more opportunities (or game activities) to participate. The results from SPSS also suggest that the blind participants could outperform experienced sighted participants in the context of sound-only games (see Appendix 9.7). Although playing the game individually could allow the participants to challenge themselves based on their own game scores, their recent game scores from this experiment indicated that their performance increases as they compete with each other in the multiplayer environment. Probably, single-player games could only attract players with superior cognitive ability and skills, or those who do not prefer competing with other players (Habgood and Overmars, 2006).

From the table above, group two has the biggest total score since players could benefit from both practice and group working (or competition). The effects of both factors (practice and group working) are separately significant ($F = 61.34$, $df = 2$ $p < 0.001$). Clearly, this is an additional evidence to explain the importance of competition in the context of sound-only games. Similar results in other game context have been achieved in existing research (Hartmann and Klimmt, 2006; Boyle and Connolly, 2008). Vorderer, Hartmann and Klimmt (2003) also reported that competition is probably the most important aspect related to games enjoyability, and this aspect will usually increases a player's desire to play. As a final observation for this experiment, the effect of group working (competition) is at least as big as the effect of the level of practice, explaining the importance of the competition effect.

Interestingly, the regression analysis for combined data for the individual learning (group one; see Appendix 9.10) show clear fit to the exponential function ($F = 73.84$, $df = 1, 4$, $p < 0.001$) rather than the linear ($F = 71.13$, $df = 1, 4$, $p < 0.001$) or power ($F = 54.1$, $df = 1, 4$, $p < 0.001$). In fact, this is not an artifact of averaging since individually, two heroic players' results the same group could statistical significantly achieve the exponential function ($F = 37.71$, $df = 1, 4$, $p < 0.001$) over linear ($F = 20.01$, $df = 1, 4$, $p < 0.001$) or power ($F = 24.6$, $df = 1, 4$, $p < 0.001$). The second participants' score are superior too, indicating the exponential function ($F = 152.55$, $df = 1, 4$, $p < 0.001$) over linear ($F = 100.87$, $df = 1, 4$, $p < 0.001$) and power ($F = 51.24$, $df = 1, 4$, $p < 0.001$).

Surprisingly, only group working (combination of the three participants from group one in Appendix 9.7) and with individual practice effects showed statistical significant results, highlighting the improvements of group performances. However, in group competition, the non-significant result was also found, explaining that the regression effects are lost. This is an interesting result, for the first time the significant regression function was totally obliterated. The score from individual and group totals obtained from the participants showed a clear increase, explaining the increase of game performance in group competitions. So, the non-significant result may just reflect high variability in their data. If so, perhaps a larger number of trials (i.e. more than six) might show a visible significant result?

6.9 Experiment Eight

This experiment was conducted to further analyze the players' learning curves by measuring the three different learning functions (linear, power and exponential curves) since the evident from Experiment Six and Seven suggest that the power function is not the only law that will appear in the context of sound-only games. In this case, the Totally Lost 3 game is considered as one of the enjoyable games that could generate interesting results. If the exponential function explains constant learning rate reflects a fixed percentage of what remains to be learnt, then could this also explain exponential function exists due high motivation (individual differences) or serious players? On the other hand, the exponential function could also provide a subtle explanation, explaining an extent where learning improves performance. But will the exponential law be found in this experiment? Anderson (1999) argued that "the exact nature of the practice function will never be resolved." If so, this experiment is important and hopefully, could explain the motivation hypothesis over the individual differences view.

This experiment is also important to test one other hypothesis. If the results of this experiment show similar results to Experiment Seven, showing non-significant function from our participants' data, then we suggest the expectancy of high variability in their data. If so, we speculate that players' game performance should fit a learning function based on a larger number of trials as a part of the hypothesis. At the very least, a larger number of trials (i.e. more than six) might be more sensitive to produce a clearer learning curve.

6.9.1 Methods

This experiment is divided into two phases. A total of eleven new participants were recruited for this experiment. They are a mixture of Malaysian (consist of seven males and four females) participants of age ranged between 17 to 24 years. Although they are computer game experts who have played many different types of computer games (including many sound-only computer games), they came from very poor families and are expected to have greater sense of money. If so, more money as reward should reflect greater motivation or significant changes in their current emotion and behavior. The experiment session took place in house (a room) with six different laptops, in Malaysia. All the participants have been given verbal instructions and guide before playing the game. They were asked to participate in the mouse tutorial session before playing the game. As elaborated in Chapter 5 (see Section 5.2.1.5 The Feasibility of Computer Mouse in Sound-only Computer Games), the mouse tutorial is a computer application for blind users to use as a part of the computer mouse training.

So, in phase one, six participants have been offered a GBP 10 note with the condition of scoring 100 game points in the Totally Lost 3 game within six trials. If they could score 130 game points, they will be given a GBP 5 note extra. Those who could not achieve at least 100 game points will not receive any reward. In phase two, five new participants were invited to play the Totally Lost 3 game individually for thirty trials. The rewarding system has slightly changed. This time, the top scorer for the thirty trials (total game scores) will receive GBP 100 note (two GBP 50 note) as reward. Participants were informed that their data will be used for comparison purpose. Before starting the game, they were told that the top score for this game is 210 points, scored by a sighted non-musician player when playing the game for fun.

Participants were given plenty of time to complete their task since they complained that using the headphone overtime will produce heat in their ears (in Phase Two of this experiment), subsequently reducing their game performances. Focusing too much in a game will reduce their performance too. Some of the participants took at least a week to complete the thirty game trials. Generally, all of them took at least a short break after playing the game every trial.

6.9.2 Results and Discussion (Phase One)

The regression analysis was performed in SPSS.

Six new highly motivated non-musician participants were invited to play the Totally Lost 3 game for six trials. This section further understand how motivation increase the efficiency of task performance since presumably, the greater the motivation refers to better performance. Moreover, the correct motivation strategy should bring positive results to the task (Vallabhaneni, 2009). Holland and Gallagher (2004) reported that expectancy is very important that will guide a person's learning and behavior effectively. People will usually work very hard if they have a good chance to receive great rewards in return. Before starting the experiment, the participants were told about the reward by mean of lottery. In detail, each participant will be rewarded a GBP 10 note if they could score 100 game points within the six trials. Additionally, a GBP 5 note will be given to them if they could reach 130 game points. Finally, as reported by Vallabhaneni (2009), performance and satisfaction could both be improved with proper motivation. Hopefully some participants' game score could support the exponential learning function here, assuming that the Totally Lost 3 game is enjoyable for them. However, the reward might not be proper, as explained by Herzberg in his two-factor motivation theory (1959); money is sometimes a weak motivational tool. So, if the players' performance do produce any exponential learning function, a stronger motivational tool should be considered to stimulate the users' satisfaction to explain the individual differences hypothesis.

Participant	**Linear**	**Power**	**Exponential**
s1	F=43.27, df=1,4, p=<0.001	F=17.36, df=1,4, p=<0.001	**F=47.90, df=1,4, p=<0.001**
s2	F=5.28, df=1,4, p=<0.001	**F=6.45, df=1,4, p=<0.001**	F=5.27, df=1,4, p=<0.001
s3	F=6.30, df=1,4, p=<0.001	F=3.10, df=1,4, p=<0.001	**F=7.05, df=1,4, p=<0.001**
s4	n.s.	n.s.	n.s.
s5	**F=23.05, df=1,4, p=<0.001**	F=8.41, df=1,4, p=<0.001	F=16.71, df=1,4, p=<0.001
s6	n.s.	n.s.	n.s.
totalScores	F=16.54, df=1,4, p=<0.001	F=6.36, df=1,4, p=<0.001	**F=18.76, df=1,4, p=<0.001**

table 6.8 Regression Analysis for Six New Sighted Non-Musician Participants

The table above (see Table 6.8) shows the full regression analysis of six new sighted non-musician participants. First and most importantly, the regression analysis on the totals of this group found that the exponential function was a significant fit ($F = 18.76$, $df = 1, 4$, $p < 0.001$) and the best fit for the combined data. The linear and power functions also fit significantly but less prominently.

However, when looking at the individual learning curves, the regression analyses showed only two participants (S1 and S3, out of six participants) whose data could support the exponential function. Only one participant (S2) whose game score fits the power function and another (S5) supports the linear function. Unfortunately, there were two participants showed non-significant functions (S4 and S6) in this section. Initially, this experiment attempted to produce high levels of motivation based on the rewarding system. So, these interesting results support the hypothesis that an exponential function is associated with highly motivated performance. Perhaps lab studies will find power functions when associated with bored participants.

Whilst the individual participants' scores showing different function and some were non-significant results, this just reflects high variability in their data. The results have clearly shown that money is a powerful motivational tool and could motivate the participant by satisfying them. The two participants' results support the two exponential learning functions. Perhaps more money could help to stimulate the participants' game performance? On the other hand, more game trials should also be considered to produce, hopefully more sensitive and visible results.

6.9.3 Results and Discussion (Phase Two)

Four new sighted non-musician participants were recruited to participate in this experiment. Assuming that the results from Phase One may be due to the differences of motivation levels, the next prediction will test the changing shape of the learning curve to analyze if the participants' results could support the exponential function than any other functions. If that happens, a new explanation could have been crafted, such as explaining the reward used here could strongly motivate our new players. Again, the recruited participants are very poor people where money is something very important for them. Greater reward (GBP 100 note as reward) has been offered for top scorer whose total score are higher than the other three participants. Their results were analyzed in SPSS.

Participant	Linear	Power	Exponential
s1	F=54.55, df=1,28, p=<0.001	F=49.23, df=1,28, p=<0.001	**F=56.80, df=1,28, p=<0.001**
s2	F=102.76, df=1,28, p=<0.001	F=91.27, df=1,28, p=<0.001	**F=110.41, df=1,28, p=<0.001**
s3	F=3.62, df=1,28, p=<0.001	F=3.84, df=1,28, p=<0.001	**F=3.96, df=1,28, p=<0.001**
s4	F=57.16, df=1,28, p=<0.001	F=55.03, df=1,28, p=<0.001	**F=57.58, df=1,28, p=<0.001**
totalScores	**F=133.38, df=1,28, p=<0.001**	F=100.52, df=1,28, p=<0.001	F=125.06, df=1,28, p=<0.001

table 6.9 Regression Analysis of Four New Highly Motivated Participants

The four new participants' results could support one learning curve individually over thirty trials. This result supports the research hypothesis that significant number of trials could generate clearer learning functions.

Perhaps most surprisingly, all the participants' game scores could clearly fit the exponential function individually through the superior motivation, namely the rewarding system (money). Although their combined data produced a linear function rather than the exponential, we could explain that the overall data (average data) tend to reflect an artifact of averaging. Moreover, the exponential function ($F = 125.06$, $df = 1, 28$, $p < 0.001$) for the combined data is very close to the linear function ($F = 133.38$, $df = 1, 28$, $p < 0.001$). As predicted by the research hypothesis, significant numbers of game trials could produce a clearer learning function. On the other hand, very clearly, apparent exponential functions have revealed by looking at their individual game scores. So, this is not an artifact of averaging.

Money is a very powerful motivation, especially for poor people, it could help to eliminate dissatisfaction or increases satisfaction level (The participants here suggest that the game is originally enjoyable, money could only extend their interest to play it longer), or both. If money could increase their game performance (comparison between phase one and two of this experiment), these players could generate higher game scores if they were given more money (i.e. 1000 for top scorer of 100 game trials). This hypothesis deserves further observation in future research.

The participants played the game on an interval basis, and have spent many hours to complete the (20 or 30) trials. Doing a task continuously without a break will generate some boredom effect. This applies to playing any games. All the participants suggest emotional and environmental interruptions such as discomfort and stress, and dissatisfaction could severely impair their game performance, similar results reported by Kirmeyer (1988) and Bailey et al (2001) in different conditions, noticeably found in this context. Perhaps the lack of superiority in sound processing skills they possessed compared to other sound professionals, e.g. absolute pitch musicians and blind people found from Experiment Six. They have to really focus on the sound produced by the game in a very quiet environment.

Chapter 7

General Discussions

7.1 Introduction

This chapter provides additional evaluations of the design of sound-only games with different approaches (than those experiments conducted in Chapter 6), particularly with the volunteer participants based on their self-report and group discussions. To date, a range of different participants have been gathered, ranging from sighted to blind people to musicians, in order to test the four sound-only computer games deployed, namely Drive, Totally Lost, Totally Lost 2 and Totally Lost 3. There are a total of 91 evaluators who participated in discussion sessions. Additionally, professional evaluators were recruited to discuss the Totally Lost 2 and the Totally Lost 3 games. Most of the participants who have participated any of the experiments (Experiment One to Eight) will participate in the discussion session to review their personal game experiences and game performances further . The aim of the participant's self-report sessions is that they will provide prominent evaluative insights into the designs of the four sound-focused games. There is one discussion session conducted with expert game players and professional musicians. They were asked to evaluate the Totally Lost 2 and Totally Lost 3 game based upon the HUNGS heuristics. The outcome of the evaluation is very constructive. First, the Totally Lost game was recognized as too simple, so the difficulty level of the game has been raised. Then, the Totally Lost 2 game was developed. The storyline of the Totally Lost 2 game was added, based on the HUNGS heuristics (cognitive models). An interactive sound-based menu was added in this game. Our evaluators and participants suggested that the Totally Lost 2 game was fun and challenging, however the game produces too much stress. It produces complications if played too regularly and consume too much memory. The Totally Lost 3 game was designed based upon the Totally Lost 2 game. The complexity of the Totally Lost 3 game has been adjusted. This game received positive suggestions by our participants and evaluators. All the evaluators who have contributed their feedback in the discussion session have played the game for many attempts before evaluating it.

Overall, from the discussion sessions, the complexity of the game is the most important aspect to determine what makes an enjoyable and challenging game. An effective sound-only computer game should be made simpler to promote player learning (Adams, 2009), but also contain some complex game elements too (Rapeepisarn and Wong et al, 2008) so different players (novice and experts) could participate and enjoy playing it together. The conclusion of this chapter highlights the overall finding, implying novel combination of game aspects to determine truly enjoyable sound-only games.

7.2 Participant's Self-Report

7.2.1 Evaluating Drive

7.2.1.1 Methods

The discussion session for the Drive game involves qualitative measures of player's self-report, face-to-face verbal interview and observation to collect their opinion (e.g. accessibility, usability, enjoyability etc.) of the game. The discussion session for this study is divided into two: (1) discussing the game with six different volunteers individually in their home, in the United Kingdom, and (2) discussing the game with thirty-five different undergraduate students in a laboratory at Middlesex University, London.

7.2.1.2 Discussion

Fifty volunteer participants (eleven participants participated in the first two experiments in Chapter Six) have discussed the pros and cons of the design of the Drive game in two laboratory sessions at Middlesex University, London (UK). According to the volunteers, the game is very user friendly where the instructional sound produces sufficient information for the user. Though some volunteers suggest changing the background music entirely, others suggest the music is fine to keep the game challenging. All volunteers suggest that the volume of the background music is acceptable where it will not produce an additional burden on the players when playing the game. The game is too simple when the difficulty level is extremely low.

The game is too simplistic, but its content makes it enjoyable. Most players will usually feel bored if practicing simple computer games for many times (Resnick and Sherer, 1994). If the simplistic content of the game makes it too simple, the game may not contain sufficient overload to make it sufficiently challenging. Perhaps the game is best targeting at visually impaired children who sometimes require lesser skills to play computer games. As an evident, complex computer games are usually harder to be played by children due to their cognitive skills and development (Van Evra, 2004).

Some students suggest removing the background music entirely or increase the intensity of other sound objects. They believe that the game instructions would be more salient if no background music distracts from it. A large proportion of students from Experiment One and Two comment the following:

1. The game does not have a pause function where it allows the player to pause the game.
2. The game does not have a function to return to the main menu when playing the game.
3. Some terms in the game are too complex, and should be adjusted so people who have little knowledge (novices) in computer games can still understand the game.
4. People who cannot perform quickly (slow reactions) with sound perception and typing skills (motor) will not able to play the game properly.
5. The tutorial is too simple, did not provide sufficient help to guide the player, so not everyone could understand the game play after listening to the tutorial.
6. The looping-style game play will easily fatigue the player.

Overall, the volunteers reported that the game is too simple. The game designer should consider complex features to increase the intrinsic challenge of the game because a simple game will not increase player's desire to continue playing the game after many trials. Moreover, a useful game should help blind users to improve their sound based perceptual skills so they can utilize such skills in the real world context. Other students claimed that the game is not enjoyable because they still prefer playing visual games.

7.2.2 Evaluation: Totally Lost 1

7.2.2.1 Methods

There were three discussion sessions conducted with fifty-one undergraduate students (thirty-nine students here have previously participated in the Drive game discussion session). They were divided into three different groups (seventeen new students were recruited in this session) in the computer laboratory at Middlesex University, London. The purpose is to briefly discuss their opinions and suggestions about the Totally Lost game. The game was presented via a projector screen in the laboratory, providing them some insight into the games. This session took approximately one hour.

7.2.2.2 Discussion

Most students comment similarly. They suggest some positive points of the Totally Lost game: (1) the idea of the game is brilliant where it involves only sound cue, memory and attention (2) the game is extremely challenging and competitive when they try to achieve higher game scores at every attempt (3) the game is very simple where it only require the usage of a mouse and headphones to play (4) the game ends very quickly and so the players would be able to restart the game immediately after losing (5) the beeping sound is appropriate, indicating danger to the player to avoid approaching that indicated location (6) the position of every sound cue (left and right position) is appropriate, and (7) the background music is very entertaining, providing a more competitive environment for players who enjoy heavy music when playing the game.

However, they also suggest some drawbacks of the game: (1) the initial volume (intensity) of the background music should be reduced (2) the game should have more varied music, i.e. a different music when the game is starting or ending since listening to the same music, repeatedly will produce fatigue (3) the students felt frustrated when they were unable to complete the game or earn higher game points than the previous game (4) the game should provide better instructional sound, indicating the left or right direction, or stronger sound predicting danger ahead (5) the volume of the instructional sound should be maximized (6) some expert students could earn higher game scores because they are good at memorizing some remaining sparse visual position of the mouse cursor, so removing the mouse cursor might reduce their performance (7) the students complained that some sections of the game produces no sound (scripting errors) (8) a sound-based timer should be implemented in the game, so they do not need to focus their attention by looking at the screen visually (9) they hope a special sound effect appears when they successfully collected something so that additional points will be given to them (10) the instructional sound (beeping) is too loud, and should be reduced to avoid frustration (11) the mouse is fine, but the sensitivity should be adjusted (12) an in-game tutorial is important to provide some understanding of the game (13) an interactive menu is necessary (14) the complexity of the game is too high, where only serious players could play and complete the game, and (15) more time allowance should be given to the player.

The fifty-one students who have participated the discussion session for the Totally Lost game indicated that the game is sufficiently acceptable and interesting; they were able to navigate the maze with auditory cues provided. Some participants were unwilling to give up the remaining, sparse visual cues namely the mouse cursor seen on an otherwise blank screen. They suggest that understanding of the roadmap (or completely understanding the game play) is important, as they will be able to achieve higher score. This unexpected result indicates the relative salience of the visual modality for sighted players and is an important consideration for players who recently acquired visual disabilities such as the visually impaired and blind people. These participants, with one exception, reported that they enjoyed playing the game, even though these participants were not able to reach the stage where they could recall and enter the keywords. Though the participants did not say so, their performance indicated that game difficulty was too high and will be adjusted accordingly, perhaps through the provision of levels. Clearly, the player could still enjoy the game even they could not win it (Piselli, Claypool and Doyle, 2009).

In this discussion, the volunteer students indicated that they still prefer visual computer games though they still say that the combination of sound and visual cues is what they actually prefer . A few students complained the game is very boring and difficult to be played. However, they added that they are not a patient person even when doing anything in real life.

7.2.3 Evaluation: Totally Lost 2

7.2.3.1 Methods and Discussion

The Totally Lost game content was re-calibrated based on the participants' suggestions. The concept of the Totally Lost 2 game is so similar to the Totally Lost game, except there is a storyline and some game features added into the game. More sound elements (e.g. sound effects, background music and instructional sound) were implemented to increase the interactivity of the game. A sound-based menu has been implemented in this game. There is a sound-only tutorial mode stored in the menu to provide some details of the game designed for our players before playing the full game.

A total of fifteen participants (e.g. nine musicians, four non-musicians and two blind people) were recruited for discussion. Thirteen participants from this group have participated Experiment Five (see Chapter Six). The two other participants are users with total blindness. Some of them are expert game players who have substantial experiences in game playing. All of them have been asked to play on the Totally Lost 2 game for a few attempts, and practicing the game for a minimum of ten times to understand both games before the discussion session. The purpose of this discussion is to compare the two games, evaluating if Totally Lost 2 is a better game if compared with the previous version (Totally Lost 1). If any, they were asked to describe the improvements of the game. They were also asked to evaluate the accessibility and enjoyability of the Totally Lost 2 game. The game was modified five times, based on what the evaluators have suggested. Each modification was made in response to user feedback, e.g. too complex, too simple, not enough fun, etc.

In summary, there were a few improvements indicated by the evaluators. First, the duration of time has increased by one minute in the Totally Lost 2 game. In addition, time boosters (or time extension) were introduced. This could motivate users to play, as the original time was seen as too brief. Picking a time booster will increase the time elapsed for thirty seconds. The game was also tested with different musicians and blind people since we assume they may have better sound perception than non-musicians (Trainor and Corrigal, 2010). If so, the accessibility of the game could be evaluated in numerous ways. First, the game could be played by different players including musicians and blind gamers who seldom play games. Second, musicians and blind players could have better sound perception than non-musicians. If so, their game score should reflect the exponential law of increasing learning over time if the game is truly enjoyable. The participants were asked to play the game for ten times before evaluating it. The discussion session took place in a computer laboratory in London, United Kingdom.

The design of the second games will be improved in several ways, including: removal of the visible cursor since players placed a surprisingly high level of value on it; the game level will be made easier so that players can memorize and recall the key words they are given; the background music will be improved, more instructional sound cues will be provided, i.e. a person giving directions by saying left or right or danger in front or back but the volume of those instructions is not so important.

7.2.3.2 Non-Musicians

Two male volunteers (aged of 25 to 40) claimed that the enjoyability of the game is moderate while two other male (aged of 18 to 30) volunteers insist that the game is extremely fun. They suggest that the game is fun because the game is special; a sound-focus game and the game play is so similar to visual games where players have to focus their attention and memory in the game at the same time. The game requires simultaneous interaction between listening (perception) and hand-movement (motor) when controlling the mouse. They have claimed that the introduction of the game is interesting, narrating the story of the game with cinematic style. The Totally Lost 2 game contained a simple interactive main menu where players are able to navigate with mouse-clicks. The novel concept of such games (sound-only games) with acceptable background music is that it increases the challenge of the game. The participants indicated that navigating around a blind-maze is fairly novel for them, giving them an impression of a sound-focused role playing game (RPG). They also suggested that the sound positions have produced accurate left and right positions compared to Totally Lost. The Totally Lost 2 game contained sufficient instructional sound where it could guide players to complete the game easier. Additional game features such as the time booster is important, increases the time and allows the players to perform better. In fact, this game feature is important in a way where the "better the performance, the greater the satisfaction" (Smith, 1977, p. 5.14).

Although the game is challenging, it is too difficult as the participants cannot understand the game play within few trials. Therefore, they suggest reducing some complex game features since their main attention is to focus on the position in the game and not on other features. There were too many distractions that feel complicated as the game progress. According to them, a person could not perceive too many sound cues at a time. Doing so will increase their memory workload. However, players are usually motivated to learn when they engaged in difficult activities (Taylor, 2006). Therefore, the difficulty level of the game should not significantly be reduced; else the challenge of the game will be destroyed. Another important aspect of the game is the time. The time is not sufficient for them to complete the game. Even adding time boosters will not help. Therefore, adjusting the time is an important aspect to allow the players to enjoy the game further. However, these are the main problems the four participants encountered: (1) the game is fun but they still prefer visual games since they are used to playing visual games rather than sound, and (2) the Totally Lost

2 game is definitely not suitable for novice players, or people who have no patience since they have to spend much time concentrating on analysing the route whilst concentrating on the traps found in the game. Perhaps, this game is only suitable for serious players when sound is a motivational element. They could use this element to motivate them to win the game, even if many trials are required.

7.2.3.3 Sighted Musicians

It is interesting to consider suggestions from sighted musicians, especially those who have little knowledge of computer games since they were able to evaluate the game by acting themselves as a normal user and not comparing the game directly with any other commercial interactive computer games. Although the musicians reported similarly to the non-musician players that are their game scores have proven that they do perform better than non-musicians at first. Our musicians here suggest that the game is accessible, meaning that they were able to understand the game completely after playing it for a few attempts. They indicated that the intensity of the background music has produced a challenging environment for them. All the professional musicians here are females, except one additional evaluator is a male. However, he has not participated any experiment sessions. He just played the game for few attempts before giving his valuable feedback in the discussion session.

However, there are some additional and interesting suggestions proposed by the two professional female musicians, aged 20 to 22. The two musicians have the absolute pitch ability. They commented similarly: (1) The Totally Lost 2 game is too complex, in that they will not able to win the game within few trials (2) they strongly rely on the background music when playing the game because the music will contribute partial enjoyment to the game play (3) the game is fun because it require serious attention from them, motivating them to learn whilst trying to perform better (complex sequence output) to gain higher game scores (4) the time task encourages them to learn to complete the game quicker and (5) they will stop playing the game after few trials because the game require too much concentration (attention). They feel stressed and need a break immediately. Apparently, the two professional musicians suggest that the game is not boring if not played constantly over a number of trials (i.e. 100 times) because the game provides hard fun and not relaxation (enjoyment). It is not surprising that the two professional musicians could play better than normal musicians since they possess special musical ability. They have the absolute pitch ability. Absolute pitch is recognized as perfect pitch, where the musician has the ability to recognize a pitch or a tone (or music) perfectly whilst recreating musical notes of that particular music without the need of references. If so, they should be better in any auditory activities (Tierney, Bergeson and Pisoni, 2009) than normal musicians.

The only disparaging comment made by the musicians is that the game is sometimes lacking in consistency where it will not provide help to assist the players to leave the labyrinth when they are stuck. They suggest implementing more clues to guide the player to play better. For instance, providing some instruction to indicate to the player they are heading to the wrong direction. Besides that, the mouse sensitivity should be adjusted since they are not used to controlling a mouse in computer games. Finally, only one professional musician (with absolute pitch) could win the game within twenty seven trials. She suggests that the complexity of the game motivated her to keep trying to complete the game. She spent two months in this process. In fact, she is very hard working, and is a person who like challenges in real life.

7.2.3.4 Blind Participants

The game was evaluated with two computing expert blind computer users (male and female) who are currently working in the ICT department of the Malaysian Association for the Blind. They are blind adults, aged of 40 to 48 who lost their sight since birth. They neither have played a computer game before. Conversely, blind people may have better sound perception skills than sighted people, since their circumstances could promote excellent auditory perceptual skills (Kalat, 2008). If so, a few questions have been proposed. First, will blind people outperform professional musicians (with absolute pitch ability) in their game score? This question has been answered in Experiment Six (see Chapter Six). Second, will they be able to evaluate the accessibility of the game if they seldom play computer games, or probably not playing a game before? Third, perhaps the most important question; how can we evaluate the enjoyability level of the game with different blind users who have different preferences, particularly those who do not like playing computer games? Therefore, two blind people were recruited to discuss these questions, mainly for their opinion of the Totally Lost 2 game.

These two blind users suggest the fun of controlling a character in a game is important for them, because they were treated as a hero and that feature of the game motivated them to work even harder to complete the game. Although the first blind evaluator has not played a computer game in his life, he still prefers challenging games over games with simplistic content. This is not surprising since complex games are seen as important games and contribute to learning and motivation (Martens, Diener and Malo, 2008). Both the blind evaluators suggested that the game is something new for them, the game is too challenging, requires too much complex skill (complex output sequence) and memory skills to memorize all sound cues in order to play the game. Indeed, they do not like playing a game for many trials and still not completing it. Therefore, they suggested that the Totally Lost 2 game provides "hard fun" meanings that the game is fun, but overly competitive. They have to stop playing the game immediately after a few trials and not doing anything apart from relaxing, i.e. drinking a cup of water, listening to some music etc. They also suggest reducing the complexity of the game to an extent to which players could win the game within an acceptable number of attempts.

7.2.4 Evaluation: Totally Lost 3

7.2.4.1 Methods

A total of twenty-four participants (eight blind participants, eight sighted musicians with perfect pitch and eight sighted non-musicians) took part in the Totally Lost 3 game discussion. Two blind evaluators from the eight have previously participated in the Totally Lost 2 game discussion. All the participants were asked to explore the Totally Lost 3 game by playing it so they could provide some exposure to the game before evaluating it. They were asked to play the game for five times to evaluate the feasibility of the Totally Lost 3 game system. First, they were asked to navigate the game with a mouse. Second, they were asked to participate in the tutorial mode and listen to the voice-synthesized tutorial properly. The purpose is to determine if they could entirely perceive and memorize all sound cues before playing the game. Finally, they were asked to play the game for three times. The discussion session was held in the computer laboratory in the Malaysian Association for the blind in Malaysia, where all our participants were asked to discuss their game experiences of the game.

7.2.4.2 Discussion

The design of the Totally Lost 3 game has been improved in several ways; the background music has been improved. For example, in the Totally Lost 2 game, every instructional sounds (e.g. a voice giving instructions) are computerize sound. Computerize sound here refers to those sounds created by computer software, and may sound very vague (and fake), reducing players' intrinsic challenge and comfortability when playing the game. The instructional sounds were substituted with real human voices in Totally Lost 3, to provide more realism. The storyline has been expanded to form a more interesting game. Please read the details of the storyline expansion of this game in Chapter 5.2. Since Totally Lost 2 presented too many sound cues at a time (more than six), as reported by the participants, they could not memorize every sound element clearly in order to play the game effectively. In fact, the working memory is efficient if only six or less items are stored in it at a time (LeCompte, 1999). Stress happens if more than six items present in the working memory at the same time (Broadbent, 1975). Therefore, the amount of sound cues in the Totally Lost 3 game was reduced so that players can memorize them more easily whilst playing the game with lesser burden. Unlike the Totally Lost 2 game, the loading time of the game has been reduced to lessen players' frustration. Other changes include some modifications to the sound cues. For instance, publishing the sound correctly to the left and right of the headphone. In fact, this game has no forced ending so that players will try to beat their own high score in every game. The discussion session took place in the laboratory of Malaysian Association for the Blind in Kuala Lumpur, Malaysia.

The participants have suggested that the Totally Lost 3 game is much more challenging and fun when compared to the Totally Lost 2 game. They suggested that the game created significant levels of enjoyability. The game is accessible where different game players in the present context can play and compete with each other. They do not need to practice the game for more than a few times to understand the game play. Although the game publishes most information interactively in sound cues, most sighted participants were unwilling to give up the remaining, sparse visual cues, namely the game score and the time elapsed displayed on an otherwise blank screen. Clearly, this important game aspect is not an artifact for players with visual disabilities. Interestingly, our absolute pitch musicians suggest that they could just turn off the screen and focus on sound cues to play it, and still achieve high game scores. This feature is highly important. For the first time, they can close their eyes and hallucinate as if they are playing the game in a fantasy world, unable to predict what happens next. This is also a part of entertainment that could excite them and increase their desire to play and understand more of the game.

However, as expected, the influences of practice over time may generate fatigue or cognitive overload. This was shown through some of the participants' game performance. Some participants' results supports the power law of practice, where the rate of learning decreases over time, suggesting that the enjoyability level of the game is not enough and has not reached to the stage where the levels of boredom and fatigue were mitigated. It is not surprising that the lack of challenge or requiring excessive amounts of practice in a game will generate boredom (Appelman and Wilson, 2006). The game would have been more fun, perhaps, if it provided a more competitive environment for their players, e.g. multiplayer gaming environment (Habgood and Overmars, 2006). Furthermore, as predicted, single player games may be less enjoyable when compared to online MMO (Massively Multiplayer Online) computer games. Unless new game contents were updated continually into the game from time to time, such as the Restaurant City flash-game (Playfish, 2010) on Facebook. They do implement new game contents in the game on weekly basis. Sometimes, in online computer games, players also enjoy interacting with other players, so they could learn from other players through social interaction (Rollings and Adams, 2003). This is an important consideration that promotes learning in the context of computer games.

7.3 General Review

7.3.1 Learning Curves: Form and Function

A thorough analysis of the learning curves have been analysed (in SPSS), based upon the three groups of participants' game performance (scores) conducted in the previous chapter (see Experiment Six). This analysis is important, as it explains the differences between different learning curve functions that are found in different cases. The power law has been a significant tradition in research on human learning. Many laboratory studies have found evidence in support of the power law (Rosenbloom and Newell, 1987). More recently, Josephs, Silvera and Giesler (1996) have presented counter-instances of exponential rather than power functions. This is further supported by some work conducted by Heathcote, Brown and Mewhort (2000). However, there have been few attempts to explain why these different functions arise and in what circumstances. The following data and analyses provide evidence that exponential functions occur when the participants are highly motivated, such as found when playing a stimulating computer game, whilst power functions indicate participants with lower levels of motivation, as in most laboratory experiments.

The three groups of participants' game scores were then analysed in SPSS. The regression analysis (see Appendix 9.5) shows the learning curves obtained by SPSS based upon the twenty-four participants' game scores from Experiment Six (see Chapter Six). Clearly, three learning curves have been produced rather than the expected two curves (power and exponential) in some existing research (Heathcote, Brown and Mewhort, 2000). The three curves are relatively close to each other, though, the linear curve (F = 645.11, df = 1, 4, p <0.001) is slightly greater compared to the power function (F = 241.1, df = 1, 4, p <0.001) and exponential function (F = 154.17, df = 1, 4, p <0.001). The power function is higher than the exponential here.

Most Prominent Function	**Linear**	**Power**	**Exponential**	**non-sig.**
24 Participants	3 Ss	9 Ss	3 Ss	9 Ss

table 7.1 Most Prominent Function for the Twenty-Four Participants in Experiment Six

The summary of the regression analysis for the individual participants of this experiment shows the most prominent function for the twenty-four participants who have participated in Experiment Six (see Chapter Six). Different individuals show different preferred learning functions. The combined data produced by the three participants' game performance showed clear fit to the linear function (linear = 3 Ss). Nine other participants' data produced the power law (power = 9 Ss) whilst three other participants' score showed obvious exponential function (3 Ss). However, nine other participants' data from this experiment indicates that the fits of the three functions were not statistically significant (n.s. = 9 Ss). This result, presumably, suggests higher variability of the individual's performance. In fact, these non-significant results for the nine individuals show that any learning trend can be masked by the variability of their game performance, obscuring any underlying learning trends. Overall this is an interesting and novel result, explaining that playing sound-only games may sometimes result in the production of a different learning curve than those expected (linear, power and exponential function) due to different conditions and circumstances.

The full summary of the regression analysis (see Appendix 9.6) presents the most prominent function fit for the twenty-four participants recruited. As predicted, the notion of motivation implies an exponential function for truly enjoyable computer games or truly motivated players who were motivated by the game so they could keep learning to play and keep raising their performance. However, it is impossible to estimate that the Totally Lost 3 game is not an enjoyable game by just looking at the production of a linear function for the overall totals (F = 645.11, df = 1, 4, p <0.001) especially the results were built upon combined results. Somehow, the combination data from the blind participants show a clear support to the exponential function (F = 337.85, df = 1, 4, p <0.001), with a much better and clearer fit than for linear (F = 183.96, df = 1, 4, p <0.001) or power (F = 84.47, df = 1, 4, p <0.001¿ function. Sighted participants' result show clearer power function (F = 461.53, df = 1, 4, p <0.001) individually. Finally, the absolute pitch musicians show a slightly more pronounced power function (F = 55.90, df = 1, 4, p <0.005), although the linear and exponential functions are close.

Separately from the combined data, three individual players (S16, S21 and S24; see Appendix 9.6) showed the exponential function in their game performance and three other individual players (S6, S17 and S19; see Appendix 9.6) showed the linear function. Clearly, the exponential and linear functions are not a result of combined data. So, different curve fittings are visible in various the contexts, indicating the power power law is sometimes artefactual (Heathcote, Brown and Mewhort, 2000). At the very least, the curve fitting varies depending on different context. The result shown in the graph below (see Figure 7.1), again, explained that the power law will not necessary apply to all conditions, particularly in the context of sound-only games.

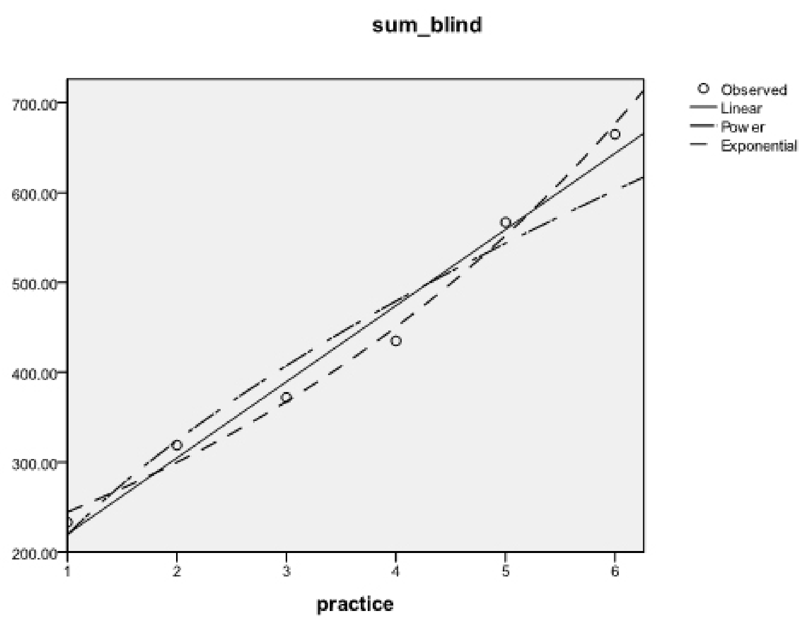


figure 7.1 Regression Analysis for the Blind Participants

There are several, equally likely explanations for these differences of learning functions for the participants. Individual differences such as motivation may affect learning curve parameters (Speelman and Kirsner, 2005) and may explain these results. Perhaps the blind people are better at learning through sound so they could achieve expertise at a quicker learning rate than other people, making them highly motivated players in sound-only computer games. The absolute pitch musicians started with better learning results than the other groups. Obviously, they are sound experts and could learn better with their superior sound skills. The sighted non-musicians are more average sound-only computer players and are more average at learning through sound or sound-related skills. Visual cues are still a top priority for them, unless they are highly motivated players who will keep learning by playing the game to achieve different skills. Overall, the exponential, power and linear functions are not just a result of aggregating the data. Such an interesting result suggests different motivational levels from the participants. It also finally shows that the Totally Lost 3 game do has its own uniqueness and enjoyability state, as explained by the participants in Experiment Eight (see Chapter Six) and the discussion session (see this Chapter).

The combination data from the blind participant's results, in Experiment Seven favoured an exponential function rather than the power or linear function. This is an interesting result, as predicted by Verwey (1996), learning rates increase with practice in many complex environments. Strangely, the regression analysis (see Appendix 9.6) showed many non-significant results for individual participants, although the only significant results, so far, seem to occur with individual working and the combined data from the regression analysis table (see Appendix 9.6).

In Experiment Eight, six new sighted non-musician participants who have strong understanding of computer games were recruited. In particular, they have extensive experience of sound-only games. They played the Totally Lost 3 game individually over six trials. Two participants (out of the six) showed non-significant learning curves. This may be due to high variability since the other four participants showed different learning functions in their results (a mixture of linear, power and exponential functions). At the very least, the rewarding system (or the reward introduced here) is an important motivation tool that will generate satisfaction for the players. However, this is still not sufficient to favour a motivation explanation over an explanation in terms of individual differences in sound-only computer games since not all participants (see Appendix 9.11) generated the exponential function in their results. Perhaps the amount money used to motivate the players is not sufficient to highly motivate them to treat the game play as highly challenging.

So, two hypotheses have been crafted. First, assuming a clearer learning function may be visible based on significant number of trials. Second, the reward should be increased to creating higher motivation levels in our players. Further regression analysis for these hypotheses has been conducted (see Appendix 9.12). Their results indicated that six trials are not enough to reliably detect a significant learning curve. Interestingly, all of them scored very well and produced exponential functions individually. Although their combined data produces the linear function rather than exponential (see Appendix 9.12), the two functions are relatively close to each other. The linear function is thus an artifact of averaging. So, finally, the conclusion is that these positive results support the two hypotheses above.

Chapter 8

Conclusion

8.1 Discussion

People play computer games because computer games are enjoyable. In fact, do we know what makes the game enjoyable? Some game players, especially male gamers enjoy playing war game because they find it motivating (Bonanno and Kommers, 2005). On the other hand, some hardcore game players could play games for many hours for many reasons (Kristiansen, 2008). Obviously, they really prefer to have serious challenges from the computer game, so they could be successful in the game (i.e. becoming the best player in the game; Klug and Schell, 2006). Does that mean that player's motivation to play increases the enjoyability level or does becoming successful in the game form a goal in itself?

The results of the experiments in Chapter Six have reported some improvements for the evaluation methods. Obviously, game designers should consider some other game aspects such as competition among the players. The in-game game tutorial session is an additional and powerful stimulant that could motivate players to increase the intrinsic challenge of such games. Since most game players need to enjoy the initial game experiences at the very beginning, they will want to avoid confusion and increase their skills so they could progress through the game more easily (Pagulayan and Keeker, in press). Overall, these two features were treated as powerful tools of learning (Hsiao, 2007; Lin and Liu, 2010). The results in Experiment Six indicated that the number of trials could be reduced but the number of players increased (Hung and Adams, 2010). However, this suggestion seems to be reversed in Experiment Seven and Eight (see Chapter Six). More trials are definitely necessary to further evaluate the players learning experiences. Clearly, this is an important methodological proposal to improve the evaluation methods. More specifically, the influences of practice and the introduction of different secondary tasks could be useful as a part of potential evaluation method for accessible computer games.

Visually impaired users from the Malaysian Institute for the Blind suggest that they prefer challenging and competitive games. Personally, they do not prefer simplistic games. In fact, simple games usually fail to be appreciated by audiences (Walker, 2003). Complex computer games offer more valuable features (Mayer, 2008), contributing in complex skills (Juul, 2005) such as cognitive learning. However, if the content of the game is too complex, it will generate some stress effects that game players may wish to avoid (Hung and Adams, 2010). Competition was rated as the most interesting and valuable game feature for enjoyable computer games (Boyle and Connolly, 2008). In fact, competition motivates most game players to continue playing. The competition feature has been deliberately analyzed in the context of education by Dearden (1976), explaining that competition is of intrinsic value when aiming at learning and enjoyability. Similar results were produced in the context of sound-only games where six blind participants played the Totally Lost 3 game in an enriched multiplayer-form (see Experiment Seven in Chapter Six). They were asked to challenge each other face-to-face. The purpose is to determine if the provision of competition could explain the enjoyability aspect of the game. Equally, the effect of the overload was reduced significantly. Their game performances have shown significant improvements over practices. The six valuable participants data have been compared and are statistically significant (Chi-Squared = 61.34, df = 2 $p < 0.001$), indicating that playing the game in a multiplayer environment is sufficiently acceptable in a stage where they feel extremely exciting and which provides them with an explosive adrenaline boost. This is visible from their facial expression when playing the game. Clearly, the blind female participants lost to one experienced male player (who has practiced the game over the past six months) in this competition. This is not surprising as practices generate improvements in cognitive skills and performance for most tasks (Shumway and Woollacott, 2007). However, female participants generated higher game scores than other male participants who are new to the game (without practice effects), perhaps, as reported, female players could achieve higher motivation in action-music games such as the Totally Lost 3 rather than other serious and challenging games (e.g. serious war games; Bonanno and Kommers, 2005). If so, sound-only game designers should consider the competition feature as an additional stimulant for computer games that will help to increase the intrinsic motivation of blind female computer users.

As mentioned by our participants in the questionnaire, their game performance scores can be negatively impaired by their emotional or motivational state. Motivation is usually triggered by different emotions, either negatively or positively, depending on the emotional state (Schutz and Lanehart, 2002). From the information provided by the participants, emotion impairs their performance in the context of computer games. The participants enjoy playing the game, if the game is truly enjoyable, and the positive feeling will usually increase their motivation if they are feeling happy. Furthermore, again, this was proven in Experiment Eight (see Chapter Six) where the increased money increased their performance, possibly changing their emotional state from bored to happy. So, such a motivational aspect is so important such that game designers should not overlook it. Else, negative emotions such as sadness, disappointment and fear will reduce gaming performances. Moreover, for every game play, as reported by Klimmt and Blake (2009), game players achieve greater satisfaction if the game is acceptably easy to be played. Perhaps game designers should consider offering several difficulty levels (e.g. easy, normal and hard) so the player' could develop appropriate gaming skills (Yun, Jiang and Li, 2010) since most popular sound-only games such as "Drive" or other visual computer games (i.e. Massively Multiplayer Online Role Playing Game, or MMORPG games) do not offer this feature. For such, a player with negative emotion could still play the game effectively if the game system offers emotional management (Saari and Turpeinen et al., 2009), providing relaxation in the environment for that particular player. Valuable entertainment features such as storyline and tutorials are also important to achieve these aims (Van Lankveld and Spronck et al., 2010).

Current research supports the view that an exponential function is associated with a constant or increasing learning rate (Rosenbloom and Newell, 1987; Heathcote, Brown and Mewhort, 2000; Baddeley, 2001; Friberg and Gardenfors, 2004; Hung and Adams, 2010), unlike the traditional power law that refers to a learning rate that slows down over time. If so, the switch from a power law to an exponential function might be indicative of higher levels of motivation by game players when compared with less motivated participants in laboratory learning experiments. This suggestion merits further attention. Surprisingly, a power function provided an excellent fit to logarithmically transformed data based on averaged participant scores per block of ten trials in Experiment One (see Chapter Six). Over ninety-nine percent of the variance was explained by this function! Although the expectancy of linear or exponential relationships for log transforms has been made, but clearly the observed function is highly lawful, unlikely to be an artifact of averaging and more complex than anticipated. So, it seems that the Drive game is too simple and unmotivating (originally, the game is intended to be played by children) and not competitive enough for our adult participants so, they could not easily improve their performance over time. As a part of the research hypothesis, practically, if this function holds in other enjoyable games, then it should be relatively easy to predict player performance and motivation levels over time with new computer games.

However, more interesting results were found in Chapter Six. The participants showed significant learning effects. The participants' result (see Experiment Six, Seven and Eight) suggest two other learning functions rather than just the universal power law of practice. The exponential function has clearer fit for players who are highly motivated over a large number of trials. Higher motivation, as analyzed in Experiment Eight, depends on the reward system. The higher the reward, the stronger motivation the players could achieve. On the other hand, practice effects and group working (competition) could generate extensive learning experiences of the game to a stage where the participants' result could comment more meaningfully about it. At this time, we cannot locate other studies that explore and compare existing learning curves of their players' game performance in order to design and create accessible and enjoyable sound-only games. Thus the support for an exponential law model over a power learning law in the present context is an important new finding (Heathcote, Brown and Mewhort, 2000; Friberg and Gardenfors, 2004; Hung and Adams, 2010).

Finally, the exponential law applied to both averaged and individual data in Experiment Eight (see the results in Appendix 9.11 and 9.12), so it is definitely not an artifact of averaging. The consistency of this positive result has provided further support to the present work. Whilst the exponential function was superior in most of our analyses, the linear and power function still managed to fit some data significantly, though not as well, in most analyses. Finally, exploring the players' learning curves through providing an opportunity for the participants to play the game repeatedly did not, as some would expect, create significant levels of boredom and fatigue. However, in summary to the results of the experiments conducted, a small number of trials could sometimes not be sufficient to detect players' learning curves clearly (see Appendix 9.6) although they were given some strong reward as motivation for playing the game (see Appendix 9.11). Significant numbers of trials could produce a clearer learning function. This raised the interesting question of the significance of the different learning laws, particularly the linear versus power versus exponential. More recently, in Experiment Eight (see Chapter Six), we found that the greater the motivation (reward), the higher game score (exponential learning function) could be produced by the participants. They showed clear enjoyable learning effects from this experiment. Such a new finding for motivation in the individual differences view and different learning functions deserves further and more detail observations in the context of sound-only games.

In work or in laboratory studies, participants may reasonably be expected to dislike increases in workload, whilst in computer games, seeking extra stimulation may be part of the fun! However, the concurrent task impaired game performance significantly. This is one of the first times, as far as expected, that the effects of cognitive overload due to a secondary task have been demonstrated in the context of learning an interactive accessible computer game. The effects were smaller when compared with classical dual task results (Erev and Roth, 1998). Overload effects are usually demonstrable with serious, work-related tasks (Kirsh, 2000), so its generalization to interactive computer games is not obvious. At least two, related explanations come to mind for the reduced effect size. First, it is as if the evident pleasure experienced by the participants mediated the impact of cognitive overload. The prediction is that more pleasurable tasks are more resistant to overload effects. Second, the partial resistance to overload may be due in part to psychological, compensatory mechanisms (Broadbent, 1984), as in Simplex Two (Adams and Langdon, 2004), where the potential inefficiency of one cognitive mechanism is mitigated by a second, executive function.

Perhaps one of the most persistent claims of this thesis and rationale, as explained in Chapter Three, is that the design of our accessible sound-only games could have been improved by a more systematic approach built on the basis of the newly built cognitive architectures namely the HUNGS theory to encourage a more thorough approach to understanding game players' requirements. Such a theory generates a set of design heuristics (see Chapter Four) from a user model to act as a simple framework that will guide game designers and other practitioners. Such a powerful theory was built up from the combination of few cognitive psychology theories, such as the Simplex Two (Adams, 2007). It provides a valuable and theoretical psychological insight to understand human cognitive processes.

8.2 Overall Conclusion

Critical evaluations of new, accessible sound-focused games through experimental procedures, as shown in Experiment Five (see Chapter Six) have been conducted. On the basis of the experiment, evaluation methods have been refined based on the design of the initial game (to give Totally Lost 2 game). Both diagnostics (learning curve and cognitive overload) have been chosen, and were proved to be informative to cast light on design for a positive user experience. Player performance pointed to the difficulty level of this game in practice, rather than player enjoyment. The refined accessible game, namely the Totally Lost 3 was tested with several groups of participants. Positively, novel but surprising results were produced by the participants in Experiment Six, Seven and Eight (see Chapter Six). Further findings were generated by the blind participants in this chapter. Additionally, they explained that their game experiences are motivated highly by competition and reward (money) more than other aspects of game design. Finally, it has been confirmed that the explorations of players' different learning curves are of practical importance in providing them with sufficient exposure to the game in order to evaluate it. Future work may afford opportunities to further predict and test the shape of the emerging learning curves by looking at individual differences. Perhaps money as reward is not the only stimulant that could increase the players' motivation? Future work is required to explain motivational issues of different sound-only game players and the production of different learning curves. The introduction of a secondary counting task (explained in Chapter Five) did induce a significant and influential level of cognitive overload into accessible, interactive game playing and now gives us a basis to use different types of secondary tasks and overloads as diagnostics.

Equally of interest, though not conclusive, is the hint that the effect of the overload was reduced by game practice. If so, it can be suggested that the executive function has learned to execute task procedures more efficiently or the human system can bypass the executive function when well practiced. If so, the HUNGS theories and other theories such as Simplex Two need a capacity to bypass the executive. This result is unlikely to be due to the task having become too easy, as participants were finding it demanding at all stages of learning. However, the fact that we can have some confidence in secondary task induced cognitive overload means that future work can now explore the introduction of different types of secondary task to diagnose some of the underlying psychological processes. It should also be possible to explore the emergence of important individual differences, as reported in this research, the influences of motivation in learning. Again, further work on individual differences would be helpful. Finally, different extrinsic overloads (load external to the main game task) have been used, different results were found with intrinsic overload, where the game itself is made more demanding.

Given the findings of all the experiments conducted in Chapter Six and the effectiveness of learning with practice effect found from previous literatures (see Chapter Two), the most plausible explanation reported here is the experiences from all the sound-only game players could be extended with significant practices and group working. Significant practices could bypass the compensatory mechanism (executive function) respectively by generating an automaticity effect. Reward is considered as additional stimulation to promote a games' enjoyability. One thing that it has certainly not shown, however, is that the notion of automation can be seen as too simplistic, since processes become more effective and efficient with practice (Bryan and Harter, 1899; Blackburn, 1936; Kolers, 1976; Shiffrin and Schneider, 1977; Logan, 1979; Newell and Rosenbloom, 1981; Anderson, 1982; Macleod and Dunbar, 1988; Logan, 1988) and do not jump quickly to a state of automaticity during learning. From observation, the blind participants still make mistakes after playing the same game for many trials. Neves and Anderson (1981) suggest a second mechanism to explain various conditions, such as decrease of learning rate with practice. Other existing research (Rickard, 1997) assumed that most tasks relied heavily on other components to produce superior practice effects. So, this deserves a different set of explanations when based upon the HUNGS theory. Perhaps well practiced tasks will bypass the overload effects through the feedback management module and not the main executive for further monitoring. If so, the feedback management module (see Chapter Three) is not only a component for environmental feedback (Adams, 2007). First, the influence of well practiced tasks reduces the level of conscious central control but do not jump to a special state of automaticity. Second, it could act as a minor version of the executive function except monitoring stress in the lower mechanism, though it will provide further general feedback and learning rate, such as explanations based on users' awareness, auditory sensory and perceptual skills in the context of accessible computer games. So, a reasonable explanation is that well practiced procedures can be conducted in parallel occasionally by the feedback management rather than the central executive and therefore be virtually bypassed. Finally, a confirmation of this suggestion would again, require further work.

Different participants were recruited, ranging from sighted to blind people, and to musicians to test the sound-only games designed. The analyses in Experiment Six (see Chapter Six) indicated that blind people have to rely more on their memory to play computer games. Basically, they require a lot of memory power to deal with their daily activities (Schulze, 2001). So, memory rehearsal is an important aspect in the design of sound-only games. For such, blind people could use complex technologies such as an "iPad" or "iPhone" mobile (Apple, 2011), on daily-basis is a serious and significant contribution. Sighted non-musicians on the other hand are more devoted to visual cues and so, they could not easily outperform blind people in any sound-only game perspectives, unless the rewarding system is strong enough to highly motivate them to compete against the blind players' game score (see Experiment Eight). Obviously, blind people have stronger auditory perception and performance skills. They could easily outperform any sighted participants in any auditory tasks. Interestingly, all groups of participants recruited here (sighted, musicians with absolute pitch and blind users) showed different learning curves. Absolute pitch musicians start their performance with a positive superiority (higher intercept) that dissipated with practice. That may reflect superior auditory processing skills, but reduced motivational skills.

Apparently, the musicians with the absolute pitch ability did not score brilliantly in Experiment Six (see Chapter Six) when their game performance were used to compare against the sighted non-musicians and blind players. A possible explanation for this finding is that the musicians with the absolute pitch ability could perform better at the very beginning of the experiment (compared to the two other groups), but their motivation dissipated later even if they possess superior musical skills compared to other user groups. Perhaps the background music of the Totally Lost 3 game was not particularly well-chosen to motivate this group of players since the background music may play an important role to motivate musicians to play much better (explained in Chapter Seven), or their superior sound processing skills are more visible with practice. Clearly, again, studies with a larger number of participants from this group or significantly more number of trials should solve this problem.

However, there is one more conclusion. Further accessible computer game research should also look at game play and not always only at inspecting the usability of the game system. In summary, as explained in Chapter Three, there are some really important game play features such as the reward system. This aspect should be considered critically by all game designers. Naatenen (1973) identified that reward, significance of interest, stimulating environment, and positive feedback from a particular task are recognized as important sources of motivation to the user. Since the reward system was claimed as a powerful motivation by game players (Rogers, 2010) and our game players who have participated in Experiment Eight, assuming that game designers should consider rewarding themselves too so they could motivate themselves to create a better and more interesting game for their players. Other stimulating game features, such as those mentioned in this chapter (see Chapter Eight), includes an interactive storyline for a particular game. Of course, the storyline of the game will not highly impact the game even if the storyline is not well presented (Rollings and Adams, 2003). However, it is still important and is considered as a valuable feature in the role of games enjoyability.

Based on the experiences in gathering data and from user's feedback, finally, there are still a large number of new areas to be explored in accessible, interactive game design. Specifically they include new development areas to improve game playing experience (based on the reward system), applying new concepts to game design considerations, understanding human cognitive processes better in order to increase the accessibility, individual differences and motivation, and the usability of computer games, particularly for people with vision impairment or vision loss.

Chapter 9

Appendix

9.1 Comparative Intensities of Common Sounds (Smith, 1999)

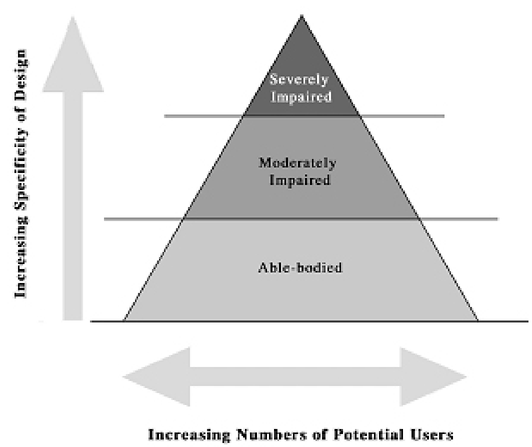
Sound in Source Intensities	In Decibels
Rocket launching pad	180
Gunshot blast, jet plane	140
Threshold of pain	120
Thunderclap	
Pneumatic hammer at 3 feet	
Amplified rock music performance in stage arena	
Interior factory noise	110
Chain saw	100
Motorcycle at full throttle at 3 feet	95
Lawn mower	90 (threshold of stress)
Applause in an enclosed auditorium	
Large truck at 50 feet	85
Average city traffic	80
Garbage disposal	
Alarm clock at 2 feet	
Human shout at 3 feet	75

Moderate surf at 10 to 15 feet	
Telephone ring at 10 feet	
Passenger cars at 50 feet	70
Large dog barking at 50 feet	
Vacuum cleaner	
Hair dryer	
Noisy restaurant	
Conversation at 3 feet	60
Birds at 10 feet	
Air conditioner at 20 feet	
Automobile at 30 feet	
Light traffic	50
Quiet office noise	
Subdued conversation	40
Wind in trees at 10 miles per hour	
Refrigerator	
Quiet garden	30
Whispered conversation	
Ticking of watch at ear	20
Rustle of leaves	10
Threshold of audibility	0

9.2 Typical concepts associate with energetics and information processing (Hockey et al., 1986, p. 427)

Energetics	Information Processing
Stress	Processor
Activation	Store
Arousal	Representation
Effort	Code
	serial/ parallel

9.3 Figure 9.3: Benktzon's design pyramid (Benktzon, 1993)



9.4 Principles of Inclusive Design (Center for Universal Design, 1995)

Principle	Description
Equitable	The product is useful and marketable to people with a range of abilities
Flexible	It can accommodate a wide range of individual needs and preferences
Intuitive	The product is easy to use
Effective	It works in most situation and for most people
Tolerant	The product can cope with user-errors
Efficient	It does not stress or tire the user
Appropriate	It is ergonomically designed to be acceptable to the majority of users

9.5 Curve Fittings for Combined Data (Experiment Six)

24 Participants	Linear	Power	Exponential
experiment6	F=326.70, df=1,4, p=<0.001	F=115.32, df=1,4, p=<0.001	F=229.47, df=1,4, p=<0.001

9.6 Full Regression Analysis of Game Performance from the Twenty-four Participants (Experiment Six)

Overall	**Linear=3 Ss**	**Power=9 Ss**	**Exponential=3 Ss**	**n.s.=9 Ss**
Participant	**Linear**	**Power**	**Exponential**	**Overall**
Musicians (M)	F=53.68, df=1,4, p=<0.005	**F=55.90, df=1,4, p=<0.005**	F=46.18, df=1,4, p=<0.005	Power
Sighted (S)	F=94.44, df=1,4, p=<0.001	**F=461.53, df=1,4, p=<0.001**	F=41.26, df=1,4, p=<0.005	Power
Blind (B)	F=183.96, df=1,4, p=<0.001	F=84.47, df=1,4, p=<0.005	**F=337.85, df=1,4, p=<0.001**	Exponential
Overall	**F=645.21, df=1,4, p=<0.001**	F=241.08, df=1,4, p=<0.001	F=154.17, df=1,4, p=<0.001	Linear
s1 (M)	n.s.	n.s.	n.s.	n.s.
s2 (M)	n.s.	n.s.	n.s.	n.s.
s3 (M)	n.s.	n.s.	n.s.	n.s.
s4 (M)	F=12.52, df=1,4, p=<0.005	**F=13.61, df=1,4, p=<0.005**	F=12.18, df=1,4, p=<0.005	Power
s5 (M)	n.s.	n.s.	n.s.	n.s.
s6 (M)	**F=18.57, df=1,4, p=<0.005**	F=14.64, df=1,4, p=<0.005	F=17.49, df=1,4, p=<0.005	Linear
s7 (M)	F=26.98, df=1,4, p=<0.001	**F=27.04, df=1,4, p=<0.001**	F=25.81, df=1,4, p=<0.001	Power
s8 (M)	n.s.	n.s.	n.s.	n.s.
s9 (S)	F=5.76, df=1,4, p=n.s.	**F=9.59, df=1,4, p=<0.001**	F=7.17, df=1,4, p=0.055 n.s.	Power

s10 (S)	F=52.14, df=1,4, p=<0.002	**F=77.77, df=1,4, p=<0.001**	F=46.13, df=1,4, p=<0.001	Power
s11 (S)	F=12.22, df=1,4, p=<0.005	**F=26.22, df=1,4, p=<0.001**	F=11.77, df=1,4, p=<0.005	Power
s12 (S)	F=8.92, df=1,4, p=<0.005	**F=16.94, df=1,4, p=<0.005**	F=8.53, df=1,4, p=<0.005	Power
s13 (S)	n.s.	n.s.	n.s.	n.s.
s14 (S)	F=13.08, df=1,4, p=<0.005	**F=27.12, df=1,4, p=<0.008**	F=7.90, df=1,4, p=<0.005	Power
s15 (S)	F=30.45, df=1,4, p=<0.005	**F=77.02, df=1,4, p=<0.001**	F=21.91, df=1,4, p=<0.005	Power
s16 (S)	F=79.25, df=1,4, p=<0.001	F=39.48, df=1,4, p=<0.002	**F=122.19, df=1,4, p=<0.001**	Exponential
s17 (B)	**F=65.91, df=1,4, p=<0.001**	F=52.14, df=1,4, p=<0.002	F=18.27, df=1,4, p=<0.005	Linear
s18 (B)	n.s.	n.s.	n.s.	n.s.
s19 (B)	**F=41.99, df=1,4, p=<0.003**	F=17.26, df=1,4, p=<0.005	F=23.21, df=1,4, p=<0.009	Linear
s20 (B)	n.s.	n.s.	n.s.	n.s.
s21 (B)	F=20.08, df=1,4, p=<0.001	F=24.57, df=1,4, p=<0.008	**F=37.71, df=1,4, p=<0.004**	Exponential
s22 (B)	n.s.	n.s.	n.s.	n.s.
s23 (B)	F=24.47, df=1,4, p=<0.008	**F=31.75, df=1,4, p=<0.005**	F=27.27, df=1,4, p=<0.006	Power
s24 (B)	F=100.87, df=1,4, p=<0.001	F=51.24, df=1,4, p=<0.002	**F=152.55, df=1,4, p=<0.001**	Exponential

9.7 Regression Analysis for Individual Participants and Combined Group Working (Experiment Seven)

Participant	**Linear**	**Power**	**Exponential**
p1 (Blind)	F=20.01, df=1,4, p=<0.001	F=24.57, df=1,4, p=<0.001	**F=37.71, df=1,4, p=<0.001**
p2 (Blind)	F=100.87, df=1,4, p=<0.001	F=51.24, df=1,4, p=<0.001	**F=152.55, df=1,4, p=<0.001**
p3 (Blind)	F=24.47, df=1,4, p=<0.001	**F=31.75, df=1,4, p=<0.001**	F=27.23, df=1,4, p=<0.001
sump1p2p3 (Blind)	F=71.13, df=1,4, p=<0.001	F=51.11, df=1,4, p=<0.008	**F=73.83, df=1,4, p=<0.001**

9.8 Full Regression Analysis (Experiment Six)

Within-Subjects Factors

Measure:score

practice	Dependent Variable
1	VAR00002
2	VAR00003
3	VAR00004
4	VAR00005
5	VAR00006
6	VAR00007

Between-Subjects Factors

		N
group	1 (musicians)	8
	2 (sighted people)	8
	3 (blind people)	8

Variable Processing Summary

		Variables	
		Dependent	Independent
		averages	trial number
Number of Positive Values		6	6
Number of Zeros		0	0
Number of Negative Values		0	0
Number of Missing Values	User-Missing	0	0
	System-Missing	1	1

Descriptive Statistics

	group	Mean	Std. Deviation	N
VAR00002	1	43.7500	15.90822	8
	2	32.6250	23.91615	8
	3	29.1250	9.46327	8
	Total	35.1667	17.85854	24
VAR00003	1	49.8750	19.40131	8
	2	46.2500	24.72564	8
	3	39.8750	15.27311	8
	Total	45.3333	19.73447	24
VAR00004	1	53.6250	21.27331	8
	2	52.5000	20.67435	8
	3	46.5000	13.13664	8
	Total	50.8750	18.18100	24

Multivariate Tests[d]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
practice	Pillai's Trace	.841	17.999[a]	5.000	17.000	.000	.841	89.996	1.000
	Wilks' Lambda	.159	17.999[a]	5.000	17.000	.000	.841	89.996	1.000
	Hotelling's Trace	5.294	17.999[a]	5.000	17.000	.000	.841	89.996	1.000
	Roy's Largest Root	5.294	17.999[a]	5.000	17.000	.000	.841	89.996	1.000
practice * group	Pillai's Trace	.732	2.078	10.000	36.000	.053	.366	20.778	.804
	Wilks' Lambda	.393	2.024[a]	10.000	34.000	.062	.373	20.242	.785
	Hotelling's Trace	1.227	1.964	10.000	32.000	.072	.380	19.639	.763
	Roy's Largest Root	.857	3.084[c]	5.000	18.000	.035	.461	15.419	.746

a. Exact statistic

b. Computed using alpha = .05

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

VAR00005	1	52.5000	15.11858	8
	2	64.2500	23.78325	8
	3	54.3750	20.41664	8
	Total	57.0417	19.90735	24
VAR00006	1	58.8750	19.07457	8
	2	67.6250	24.17754	8
	3	70.8750	37.42970	8
	Total	65.7917	27.23645	24
VAR00007	1	61.7500	19.04693	8
	2	72.6250	21.31356	8
	3	83.1250	24.34536	8
	Total	72.5000	22.55043	24

Box's Test of Equality of Covariance Matrices[a]

Box's M	92.277
F	1.240
df1	42
df2	1309.236
Sig.	.142

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + group
Within Subjects Design: practice

Mauchly's Test of Sphericity[b]

Measure:score

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
practice	.059	54.208	14	.000	.392	.473	.200

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + group
Within Subjects Design: practice

Tests of Within-Subjects Effects

Measure: score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
practice	Sphericity Assumed	22293.451	5	4458.690	27.026	.000	.563	135.132	1.000
	Greenhouse-Geisser	22293.451	1.961	11370.648	27.026	.000	.563	52.989	1.000
	Huynh-Feldt	22293.451	2.366	9420.844	27.026	.000	.563	63.955	1.000
	Lower-bound	22293.451	1.000	22293.451	27.026	.000	.563	27.026	.999
practice * group	Sphericity Assumed	4483.361	10	448.336	2.718	.005	.206	27.176	.955
	Greenhouse-Geisser	4483.361	3.921	1143.356	2.718	.044	.206	10.656	.695
	Huynh-Feldt	4483.361	4.733	947.297	2.718	.032	.206	12.862	.760
	Lower-bound	4483.361	2.000	2241.681	2.718	.089	.206	5.435	.479
Error(practice)	Sphericity Assumed	17322.354	105	164.975					
	Greenhouse-Geisser	17322.354	41.173	420.722					
	Huynh-Feldt	17322.354	49.694	348.578					
	Lower-bound	17322.354	21.000	824.874					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure:score

Source	practice	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
practice	Linear	22156.072	1	22156.072	45.136	.000	.682	45.136	1.000
	Quadratic	5.679	1	5.679	.065	.801	.003	.065	.057
	Cubic	47.084	1	47.084	.509	.483	.024	.509	.105
	Order 4	83.585	1	83.585	1.089	.309	.049	1.089	.169
	Order 5	1.032	1	1.032	.013	.909	.001	.013	.051
practice * group	Linear	3796.190	2	1898.095	3.867	.037	.269	7.734	.634
	Quadratic	492.031	2	246.015	2.812	.083	.211	5.624	.493
	Cubic	18.067	2	9.034	.098	.907	.009	.195	.063
	Order 4	34.580	2	17.290	.225	.800	.021	.450	.081
	Order 5	142.492	2	71.246	.922	.413	.081	1.844	.188
Error(practice)	Linear	10308.295	21	490.871					
	Quadratic	1837.278	21	87.489					
	Cubic	1941.733	21	92.463					
	Order 4	1612.513	21	76.786					
	Order 5	1622.535	21	77.264					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
VAR00002	2.371	2	21	.118
VAR00003	.723	2	21	.497
VAR00004	1.172	2	21	.329
VAR00005	1.306	2	21	.292
VAR00006	2.372	2	21	.118
VAR00007	.203	2	21	.818

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + group

Within Subjects Design: practice

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	426953.340	1	426953.340	225.355	.000	.915	225.355	1.000
group	176.222	2	88.111	.047	.955	.004	.093	.056
Error	39786.271	21	1894.584					

a. Computed using alpha = .05

9.9 Regression Analysis for the Combined Data for Sighted People, Absolute Pitch Musicians and Blind People (Experiment Six)

Participant	**Linear**	**Power**	**Exponential**
sumMusician	F=53.68, df=1,4, p=<0.005	**F=55.90, df=1,4, p=<0.005**	F=46.18, df=1,4, p=<0.005
sumSighted	F=94.44, df=1,4, p=<0.001	**F=461.53, df=1,4, p=<0.001**	F=41.26, df=1,4, p=<0.005
sumBlind	F=183.96, df=1,4, p=<0.001	F=84.47, df=1,4, p=<0.005	**F=337.85, df=1,4, p=<0.001**

9.10 SPSS Analysis for the Three Groups of Participants (Experiment Seven)

Group One	**Group Two**	**Group Three**		
Individual	**Group Working with Practice**	**Individual Working Without Practice**	**Mean**	
221	498	467		
355	380	372		
490	582	435		
1066.00	**1460.00**	**1274.00**	**1266.67**	

Comparing Total Scores for the Three Groups

Chi-Squared Analysis 40267.11 31.79	37377.78 29.51	53.78 0.04	77698.67	61.34 $p < 0.001$

Comparing Total Scores for the Two Groups

Comparison for	**Group One**	**Group Two**	**Mean**	
Group One and Two	**1066**	**1460**	1263	
	Chi-Squared Analysis			61.46
	38809	38809	77618	$p < 0.001$
Group Two and Three	**1460**	**1274**	1367	
	Chi-Squared Analysis			1370
	8649	8649	17298	$p < 0.001$
Group One and Three	**1066**	**1274**	1170	
	Chi-Squared Analysis			18.49
	10816	10816	21632	$p < 0.001$

9.11 Regression Analysis for Six New Sighted Non-Musician Participants (Experiment Eight, Phase One)

Participant	**Linear**	**Power**	**Exponential**
s1	F=43.27, df=1,4, p=<0.001	F=17.36, df=1,4, p=<0.001	**F=47.90, df=1,4, p=<0.001**
s2	F=5.28, df=1,4, p=<0.001	**F=6.45, df=1,4, p=<0.001**	F=5.27, df=1,4, p=<0.001
s3	F=6.30, df=1,4, p=<0.001	F=3.10, df=1,4, p=<0.001	**F=7.05, df=1,4, p=<0.001**
s4	n.s.	n.s.	n.s.
s5	**F=23.05, df=1,4, p=<0.001**	F=8.41, df=1,4, p=<0.001	F=16.71, df=1,4, p=<0.001
s6	n.s.	n.s.	n.s.
totalScores	F=16.54, df=1,4, p=<0.001	F=6.36, df=1,4, p=<0.001	**F=18.76, df=1,4, p=<0.001**

9.12 Regression Analysis of Four New Highly Motivated Participants (Experiment Eight, Phase Two)

Participant	Linear	Power	Exponential
s1	F=54.55, df=1,28, p=<0.001	F=49.23, df=1,28, p=<0.001	**F=56.80, df=1,28, p=<0.001**
s2	F=102.76, df=1,28, p=<0.001	F=91.27, df=1,28, p=<0.001	**F=110.41, df=1,28, p=<0.001**
s3	F=3.62, df=1,28, p=<0.001	F=3.84, df=1,28, p=<0.001	**F=3.96, df=1,28, p=<0.001**
s4	F=57.16, df=1,28, p=<0.001	F=55.03, df=1,28, p=<0.001	**F=57.58, df=1,28, p=<0.001**
totalScores	**F=133.38, df=1,28, p=<0.001**	F=100.52, df=1,28, p=<0.001	F=125.06, df=1,28, p=<0.001

9.13 Survey Questionnaire Form (Template)

1. Choose your gender (please choose one): male or female
2. How old are you? (please specify):
3. Ethnics? (please specify):
4. Types of Blindness? (if any, please specify):
5. When do you have such disability? (if any, please specify):
6. Rate your current emotion (e.g. 1 = unhappy, 5 = normal, 10 = very happy):

   1 2 3 4 5 6 7 8 9 10

7. How often do you play computer games? (please choose one): Yes, Sometimes, Not at all
8. What types of game do you prefer? (please tick those that apply):

   Shooting, Racing, Puzzle, Board Game, Sports, Fighting, Adventure RPG, Arcade, Others:

9. Are you good at playing computer games? (e.g. 1 = not good, 5 = moderate, 10 = very good):

   1 2 3 4 5 6 7 8 9 10

10. Do you like playing the game? (e.g. 1 = no, 5 = moderate, 10 = love):

    1 2 3 4 5 6 7 8 9 10

11. Is the game enjoyable for you? (e.g. 1 = no, 5 = moderate, 10 = yes):

    1 2 3 4 5 6 7 8 9 10

12. Rate the level of difficulty for the game? (e.g. 1 = too easy, 5 = moderate, 10 = too hard):

    1 2 3 4 5 6 7 8 9 10

13. Is the volume of the background music too loud, making the game too hard to play? (choose):

    Yes, please reduce the volume

    No, the volume level won't make a difference to the game play

    The music should be taken out completely from the game

14. Is the in-game instructional sound giving good direction to you?

(please rate, e.g. 1 = no, 5 = moderate, 10 = yes):

   1 2 3 4 5 6 7 8 9 10

15. Do you think adding more in-game instructional sound is useful?
(please rate, e.g. 1 = no, 5 = moderate, 10 = yes):

    1 2 3 4 5 6 7 8 9 10

16. How do you think the instructional sound could be improved? (choose one):

    Increase the volume of the sound

    The game should have more instruction to give better direction

    Reduce some of the instructional sound

    No changes to the instructional sound are required

    Others:

17. Evaluate the accessibility of the game? (e.g. 1 = bad, 5 = moderate, 10 = good):

    1 2 3 4 5 6 7 8 9 10

18. Which game controller is better for you? (choose one):

    Please substitute the mouse with the keyboard

    Using the mouse in this game is fine for me

19. Do you think the game could be improved?

    Any comments? (please specify):

20. Please fill in your game scores here?

    Game 1:

    Game 2:
    Game 3:
    Game 4:
    Game 5:
    Game 6:

Chapter 10

References

A

Abascal, J., and Nicolle, C. (2001). Why Inclusive Design Guidelines? Inclusive design guidelines for HCI, Nicolle, C., and Abascal, J. (Eds.), CRC Press, 3-16.

Adams, E. (2009) Fundamentals of Game Design. New Riders.

Adams, G. (2005) Blind Gamers Get Theiro Own Titles, BBC News Channel. http://news.bbc.co.uk/1/hi/technology/4112725.stm [Accessed October 02, 2011]

Adams, R. G. (1974) Pre-Sleep Ingestion of Two Hyponotic Drugs and Subsequent Performance. Psychopharmacological, 40, pp. 185-190.

Adams, R (2005a) Natural Computing. In Adams, R. (ed.) Computing and Interactive System Design. Pearson, Essex, UK.

Adams, R. (2005b) Natural Computing and Interactive System Design. Pearson, Essex, UK.

Adams, R. (2006) Applying Advanced Concepts of Cognitive Overload and Augmentation in Practice; the Future of Overload. Foundations of Augmented Cognition, Second Edition. Schmorrow, D., Stanney, K. M. and Reeves, L. M. (Eds.), Arlington, VA, Strategic Analysis, 223-229..

Adams, R. G. (2007) Decision and Stress: Cognition and E-Accessibility in the in-Formation Workplace, Universal Access in the Information Society, Springer-Verlag, 5 (4), 363-379.

Adams, R., and Langdon, P. (2003) Principles and Concepts for Information and Communication Technology Design. Journal of Visual Impairment and Blindness, 97, 602-611.

Adams, R., and Langdon, P. (2003) SIMPLEX: A Simple User check Model for Inclusive Design. In Universal Access in HCI: Inclusive Design in the Information Society, Stephanidis C. (Ed.), LEA: Mahwah.

Adams, R., and Langdon, P. (2004) Assessment, Insight and Awareness in User Centered Design that Includes Users with Special Needs. In Keates, S., Clarkson, P. J., Langdon, P., and Robinson, P. (Eds.) London: Springer-Verlag.

Adams, R., Langdon, P., and Clarkson, P. J. (2002) A Systematic Basis for Developing Cognitive Assessment Methods for Assistive Technology. In Keates, S., Langdon, P., Clarkson, P. J., and Robinson, P. (Eds.) Universal Access and Assistive Technology. London: Springer, 53-62.

AGRIP (2004) AudioQuake. http://www.agrip.org.uk/about/ [Accessed August 22, 2010]

Akilli, G. K. (2006) Games and simulations: A New Approach in Education? In Games and simulations in online learning: Research and development, D. Gibson, C. Aldrich, and M. Prensky (Eds.), Idea Group Inc. (IGI), 1-20.

Albers, M. J. (1994) Age-Related Changes in Cognitive Function. In Clinical Neurology of Aging, Albert M.L., and Knoefel K. E. (Eds.), Second Edition, Oxford University Press: Oxford.

Albers, M. J. (1997) Cognitive Strain as a Factor in Effective Document Design. In Fifteen Annual conference in Computer Documentation.

Alderson, D. L. (2008) Catching the Network Science Bug: Insight and Opportunity for the Operations Researcher. Operations Research, 56, 1047-1065.

Alexandra, P., Erika, S., Carrie, L., Nina, K. (2009) Musician Enhancement for Spech-In-Noise. The Official Journal of the American Auditory Society (Ear and Hearing), Lippincott Williams and Wilkins, 30 (6), 653-661.

Allport, D. A. (1980) Cognitive Psychology: New directions, Routledge and Kegan Paul Publication, 112-153.

Alm, N. (1994) Ethical Issues in AAC Research. Methodological Issues in Research in Augmentative and Alternative Communication. In Proceedings Third ISAAC Research Symposium, Brodin, J., and Ajessibm, E. B. (Eds.), Jonkoping, University Press: Sweden, 98-104.

Alty, J. L., Rigas D., Vickers P. (1996) Sing Music as a Communication Medium.

Amarasingham, V. (2007) Press release: The Future of Game Music. Game Press Ltd., San Francisco, CA: USA, October 04, 2007.

American Heritage Dictionary (2000) Boston: Houghton Mifflin.

Amory, A., Naicker, K., Vincent, J., and Adams, C. (1999) The Use of Computer Games as an Educational Tool: Identification of Appropriate Game Types and Game Elements. In British Journal of Educational Technology, 30 (4), 311-321.

Andresen, G. (2002) Playing by Ear: Creating Blind-accessible Game. Gamasutra Article, May 20, 2002. http://www.gamasutra.com/resource guide/20020520/andersen pfv.htm [Accessed August 05, 2007]

Anderson, J. (1983) The Architecture of Cognition. Cambridge, MA: Harvard University Press.

Anderson, J. R. and Labiere, C. (1998) The Atomic Components of Thought. Mahwah, NJ: Lawrence Erlbaum Associates.

Anderson, K. (1990) The Adaptive Character of Thought. Hillsdale, NJ: LEA. http://act-r.psy.cmu.edu/ [Accessed October 08, 2010]

Anderson, R. B., and Tweney, R. D. (1997) Artifactual Power Curves in Forgetting. Memory and Cognition, 25, 724-730.

Ang, C.S., Zaphiris, P., Mahmood, S. (2006) Cognitive Load Issues in MMORPGs. Fun and Game 2006. England.

Ang, C. S., Zaphiris, P., and Mahmood, S. (2007) A Model of Cognitive Load in Massively Multiplayer Online Role Playing Games. Interacting with Computers, 19 (2), ScienceDirect, 167-179.

Appelman, R. L., and Wilson, J. H. (2006) Games and Simulations for Training. Handbook of Human Performance Technology: Principles, Practices, and Potential, Pershing, J. A. (Ed.), John Wiley and Sons, 414-436.

Apple Inc. (2011). iPhone. http://www.apple.com/iphone

Archambault, D. (2002) Computers for the Development of Young Disabled Children. Computer Helping People with Special Needs: 8th International Conference, ICCHP 2002, Linz, Austria, Springer Berlin, vol. 2398, pp. 170.

Archambault, D. (2004) The TiM Project: Overview of Results. Computers Helping People with Special Needs: 9th International Conference, ICCHP 2004, Paris, France, July 7-9, 2004 ; proceedings", Miesenberger, K., Klaus, J., Burger, D., and Zagler, W. (Eds.). Springer, 248-256.

Archambault, D., Gaudy, T., Miesenberger, K., Natkin, S., and Ossmann, R. (2008) Towards Generalised Accessibility of Computer Games. In Technologies for E-Learning and Digital Entertainment: 3rd International Conference, Edutainment 2008, Nanjing, China, June 25-27, 2008, Pan, Z., Zhang, X., Rhalibi, A. E., Woo, W., and Li, Y. (Eds.), Springer, 518-527.

Archambault, D., Ossmann, R., Gaudy, T., and Miesenberger, K. (2007) Computer games and visually impaired people. In The European Journal for the Informatics Professional (UPGRADE), Information Technologies for Visually Impaired People, vol. 8(2), pp. 43-53.

Atakan, S. S. (2006) Human-computer interaction. Cengage Learning EMEA.

Atkinson, M. T., and Gucukoglu, S. (2004-2007) The AGRIP Project. http://www.agrip.org.uk/ [Accessed May 01, 2009]

Atkinson, R. C. and Shiffrin, R. M. (1968) Human Memory: A Proposed System and Its Control Processes. The Psychology of Learning and Motivation: Advances in Research and Theory, K.W. Spence and J.T. Spence (Eds.), New York: Academic Press, 2, 742-775.

AudioGames (2002) AudioGames.net. http://www.audiogames.net [Accessed October 01, 2006]

Axelsson, A., and Regan, T. (2006) Playing Online. Playing Video Games: Motivates, Responses, and Consequences, Vorderer, P., and Bryant, J. (Ed). Routledge 2006, 291-306.

B

Baars, B. J., and Gage, N. M. (2010) Cognition, Brain and Conciousness: Introduction to Cognitive Neuroscience. Academic Press.

Baauw, E., Bekker, M. M., and Barendregt, W. (2005) A Structured Expert Evaluation Method for the Evaluation of Children's Computer Games. Human-Computer Interaction - INTERACT 2005: IFIP TC13 International Conference, Rome, Italy, September 12-16, 2005 : Proceedings", Constabile, M. F., and Paterno, F. (Eds.), Birkhauser, 457-469.

Baddeley, A.D. (1986) Working Memory. Oxford: Clarendon Press.

Baddeley, A. D. (1990) Working Memory: Human Memory, Theory and Practice. United Kingdom: Lawrence Erlbaum Associates.

Baddeley, A. D. (1998) Human memory. Boston: Allyn and Bacon.

Baddeley, A. D. (2001) Is Working Memory Still Working? American Psychologist, 56, 849-864.

Baddeley, A. D., and Hitch, G. J. (1974) Working memory. In Recent Advances in Learning and Motivation, Bower, G. A. (Ed.), New York: Academic Press, 8, 47-90.

Badii, A., and Zhang, W. (2001) Holistic Heuristic Evaluation of Web-Enabled Enterprise Knowledge Integration Systems Using the C-Assure Methodology. In "Eighth European Conference on Information Technology Evaluation: Oriel College, Oxford, United Kingdom, 17-18 September 2001", Brown, A., and Remenyi, D. (eds.), Academic Conferences Limited, 499-508.

Bailey, B. P., Konstan, J. A., and Carlis, J. V. (2001) The Effects of Interruptions on Task Performance, annoyance, and Anxiety in the User Interface. Human-Computer Interaction - INTERACT 2001 Conference Proceedings, IOS Press, 593-601.

Bailey, G. (1995) Iterative Methodology and Designer Training in Human-Computer Interfaces Design. In Proceedings of CHI 1995, ACM Press, New York 1995, 198-205.

Baptiste, N., Tornil, B., and Encelle, B. (2004) Using SVG and a Force Feedback Mouse to Enable Blind People to Access "Graphical" Web Based Documents. In "Proceedings of Computers helping people with special needs: 9th international conference, ICCHP 2004, Paris, France, July 7-9, 2004", Miesenberger, K. et al. (Eds.), Springer-Verlag, Berlin, Heidelberg, 3118 (lecture notes in computer science), 228-235.

Bartlett, F.C. (1932) Remembering: An Experimental and Social Study. Cambridge: Cambridge University Press.

Barlette, F. C. (1958) Thinking. New York, Basic Books.

Battista, M., and Clements, D. H. (1984) A Case for a Logo-Based Elementary School Geometry Curriculum. Arithmetic Teacher, 36, 11-17.

Bauld, A., Svensson, H., Archambault, D., and Burger, D. (2002) Multimedia Games for Visually Impaired Children. In Proceedings of the Eight International Conference on Computers Helping People with Special Needs, Springer-Verlag, London, UK, 173-180.

Buaud, A., Archambault, D., Roussel, B., and Truchot, P. (2003) Evaluation Process Based on Users' Needs: Ergonomic Evaluation of Multimedia Games for Visually Impaired Children. In Assistive Technology: Shaping the Future, AAATE'03 Conference in Dublin: Ireland, Craddock, G. M. (Ed.), IOS Press, 11, 237-246.

Becker, C. A., and Killion, T. H. (1977) Interaction of Visual and Cognitive Effects in Word Recognition. Journal of experimental psychology: Human Perception and Performance, 3, 359-401.

Beck, J.C., and Wade, M. (2004) Got Game: How The Gamer Generation is Reshaping Business Forever, Boston, Massachusetts: Harvard Business School Press.

Beedle, J., and Wright, V. H. (2006) Perspectives from Multiplayer Video Gamers. Games and simulations in online learning: Research and development, D. Gibson, C. Aldrich and M. Prensky (Eds.), Idea Group Inc. (IGI), 150-174.

Bellis, M. (2007) The History of Telegraph and Telegraphy. About Inc., A Part of The New York Times Company. http://inventors.about.com/od/tstartinventions/a/telegraph.htm [Accessed 07 May, 2010]

Belton, J. (1992) 1950's Magnetic Sound: The Frozen Revolution. In Sound Theory Sound Practice, Altman, R. (Ed.), Routledge: New York, 154-167.

Benktzon, M., 1993, Designing for Our Future Selves: The Swedish Experience, Applied Ergonomics, 24 (1), 19-27.

Bergault, D. R. (1994) 3-D Sound for Virtual Reality and Multimedia. Academic Press, Cambridge MA.

Bernhaupt R, Eckschlager M, Tscheligi M (2007) Methods for Evaluating Games - How to Measure Usability and User Experience in Games? In: Proceedings of the international Conference on Advances in Computer Entertainment Technology (Salzburg, Austria, June 13-15, 2007). ACE '07, Volume 203. ACM, New York, NY, 309-310.

Bernhaupt R, Ijsselsteijn W, Mueller F, Tscheligi M, Wixon D (2008) Evaluating User Experiences in Games. In: CHI '08 Extended Abstracts on Human Factors in Computing Systems (Florence, Italy, April 05-10, 2008). CHI '08. ACM, New York, NY, 3905-3908.

Bernhaupt, R., Mihalic, K., and Obrist, M. (2008) Usability Evaluation Methods for Mobile Applications. In Handbook of Research on User Interface Design and Evaluation for Mobile Technology, Lumsden, J. (Ed.), Idea Group Inc (IGI), 745-758.

Blackburn, J. M. (1936) Acquisition of Skills: An Analysis of Learning Curves (IHRB Report No. 73), Washington, DC: U.S. Government Printing Office.

Blattner, M. M., G. Kramer, J. Smith, and E. Wenzel (1993) Effective Uses of Nonspeech Audio in Virtual Reality. In: Proceedings of the IEEE Symposium on Research Frontiers in Virtual Reality, San Jose, CA. (In conjunction with IEEE Visualization '93) October 25-26, 1993.

Blauert, J., (1997) Spatial hearing: The Psychoacoustics of Human Sound Localization, The MIT Press, Cambridge, MA.

Blindgames (2002) Blind Games: Software development project. $http://www.unc.edu/_rhillman/145/index.html$ [Accessed September 26, 2006]

Blizzard Entertainment, Inc (2007) World of Warcraft. http://www.worldowarcraft.com

Bloyd, L.H., Boyd, W.L., and Vanderheiden, G.C. (1990) The Graphical User Interface: Crisis, Danger and Opportunity. Journal of Visual Impairment and Blindness, 496-502.

Byl, P. B. (2004) Programming Believable Characters for Computer Games. Charles River Media.

Bly, S. (1982) Sound and Computer Information Presentation (Unpublished PhD Thesis No. UCRL53282). Lawrence Livermore National Laboratory.

Boer, J. R. (2003) Game Audio Programming. Cengage Learning.

Bogost, I. (2006). Unit Operations: An approach to Videogame Criticism. MIT Press.

Boland, L. A. (1989). The Methodology of Economic Model Building: Methodology after Samuelson. Routledge.

Bonanno, P., and Kommers, P. A. M. (2005) Gender Differences and Styles in the Use of Digital Games. Educational Psychology, 25, 13-41.

Bors, B. (2007) The Role of the Mouse in Audio Games. $http://www.game-accessibility.com/index.php?pagefile=roleMouseAudioGames$ [Accessed Febuary 26, 2011]

Botting, F. (2008) Limits of Horror: Technology, Bodies, Gothic. Manchester University Press.

Bowman, R. P., and Rotter, J. C. (1983) Computer Games: Friend or Foe? Elementary School Guidance and Counselling, 18(1), 25-34.

Boyle, E., and Connolly, T. (2008) A Review of Theories of Player Enjoyment in Playing Computer Games. In 2nd European Conference on Computer Based Learning, Stanfield, M., and Connolly, T. (Eds.), Academic Conferences Limited, 59-68.

Branch, J. W., LaBarre, J., and Szabo, N. (2006) Gaming the System: Intellectual Property Protection for the Video Game Industry.

Brandon, A. (2007) Audio for Games: Planning, Process, and Production, New Riders Games.

Bregman, A.S. (1990). Auditory Scene Analysis: The Perceptual Organization of Sound. Cambridge, Massachusetts: The MIT Press, 1990 (hardcover), or 1994 (paperback).

Brewster, S. (2008) Nonspeech Auditory Output. In The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Sears, A., and Jacko, J. A. (Eds.), CRC Press, 247-264.

Broadbent, D. E. (1952) Failures of Attention in Selective Listening. J. exp. Psychology, 44, 428-433.

Broadbent, D. E. (1954) The Role of Auditory Localization in Attention and Memory Span. Journal of Experimental Psychology, 47, 191-196.

Broadbent, D. E. (1956) Listening Between and During Practiced Auditory Distractions. Br. J. Psychology, 47, 51-60.

Broadbent, D. E. (1957) A Mechanical Model for Human Attention and Immediate Memory. Psychological Review, 64, 205-215.

Broadbent, D. E. (1958) Perception and Communication. London: Pergamon Press.

Broadbent, D. E. (1963) Differences and Interaction Between Stresses. Quarterly Journal of Experimental Psychology, 15, 205-211.

Broadbent, D. E. (1971) Decision and Stress. London: Academic Press.

Broadbent, D. E. (1975) The Magic Number Seven After Fifteen Years. In Studies in Long-Term Memory, A. Kennedy and A. Wilkes (Eds.), New York: Wiley, 3-18.

Broadbent, D. E. (1977). The Hidden Pre-Attentive Process. American Psychologist, 32, 109-118.

Broadbent, D.E. (1979) Human Performance and Noise. Handbook of Noise Control, 2nd Edition, C.M. Harris, editor, McGraw-Hill Book Company, New York, U. S. A.

Broadbent, D. E. (1984) The Maltese Cross: A New Simplistic Model for Memory. The Behavioural and Brain Sciences, 7, 55-94.

Broadhurtst, P. L. (1957) Emotionally and the Yerkes-Dodson law. Journal of Experimental Psychology, 54, 345-352.

Brungart, D. S., and Simpson, B. D. (2002) The Effects of Spatial Separation in Distance on the Informational and Energetic Masking of a Nearby Speech Signal. In J. Acoust. Soc. Am., 112, 664-676.

Brungart, D. S., and Simpson, B. D. (2002) Within-Ear and Across-Ear Interference in a Cocktail-Party Listening Task, J. Acoust. Soc. Am., 112, 2985-2995.

Bruning, R. H., Horn, C. A., and Pytlikzillig, L. M. (2003) Web-Based Learning: What Do We Know? Where do We go? Distance Education, Computer-Assisted Instruction and Congress, IAP publication.

Brunken, R., Plass, J. L., and Moreno, R. (2010) Current Issues and Open Questions in Cognitive Load Research. In Cognitive Load Theory, Plass, J. L., Moreno, R., and Brunken, R. (Eds.), Cambridge University Press, 253-272.

Bruno, R. L., and Amp, L. T. (1998) Psychophysiology of Chronic Fatigue in Young People. In NIH/CDC CFS Coordinating Committee Symposium, Chronic Fatigue in Adolescents: The State of the Art, Washington, D.C.

Bryan, W. L., and Harter, N. (1899) Studies on the Telegraphic Language. The Acquisition of a Hierarchy of Habits. Psychological Review, 6, 345-375.

Bryce, J., and Higgins, D. (2000) Optimal Experience - A Framework for Understanding the Phenomenology of Computer Use. In Simulations and Games for Transition and Change, Saunders, D., and Smalley, N. (Eds.), Routledge, 197-205.

Bryden, M. P. (1972) Perceptual Strategies, Attention and Memory in Dichotic Listening, University of Waterloo, Department of Psychology, Research Report no. 43.

Bryne, M. D. (2003) Cognitive Architecture. The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications", Jacko, J. A., and Sears, A. (Eds.), Lawrence Erlbaum Associates, 97-117.

Bryson, S., and Gerald-Yamasaki, M. (1992) The Distributed Virtual Windtunnel. (Report No. RNR-92-010). NASA Ames Research Center.

Buckley, K. E., and Anderson, C. A. (2006) A Theoretical Model of the Effects and Consequences of Playing Video Games. Chapter in P. Vorderer and J. Bryant (Eds.), Playing Video Games - Motives, Responses, and Consequences, Mahwah, NJ: Lawrence Erlbaum Associates, 363-378.

Buckner, D. N., and McGrath, J. J. (1963) A Comparison of Performances on Simple and Dual Sensory Mode Vigilance Tasks. In Vigilance: A Symposium, Buckner and McGrath (Eds.), McGraw-Hill, New York.

Burrows, D. (2002) Memory Overload: The Effects of Amount of Information, Rate of Presentation, and Reorganization. Cognitive Technology, 7, 20-30.

Buxton, W. (1989) Introduction to this Special Issue on Nonspeech Audio, Human Computer Interaction 4(1), 1-9.

C

Cacioppo, J. T., and Gardner, W. L. (1999) Emotion. Annual Review of Psychology 50, 191-214.

Card, S. K., Moran, T. P., and Newell, A. (1983) The Psychology of Human-Computer Interaction. LEA: Hillsdale.

Commission on Behavioral and Social Sciences and Education (CBASSE, 1997) Tactical Display for Soldiers: Human Factors Consideration (Chapter 6: Stress and cognitive workload), National Research Council, National Academy Press, Washington, D.C, 130-163.

Centre for Educational Research and Innovation, and Organisation for Economic Co-operation and Development (OECD, 2007) Chapter 2: How the Brain Learns Throughout Life. In Understanding the brain: The birth of a learning science, Cognitive Neuroscience, OECD Publishing.

Center for Universal Design (1995) Principles of Universal Design, Center for Universal Design: North Carolina State University.

Chandler, H.M and Chandler, R. (2011) Fundamentals of Game Development. Jones and Bartlett Learning: Sudbury, Massachusetts. Fig 3.4, 59

Chandler, P. and Sweller, J. (1991) Cognitive Load Theory and the Format of Instruction. Cognition and Instruction, vol. 8 (4), pp. 293-332 Chase, W., and Simon, H. (1973b). The mind's eye in chess. In W. G. Chase (Ed.), Visual information processing. NY: Academic.

Chang, A. (2003) Video games may hone mind, The Associated Press, The Record, Bergen County, NJ, http://www.encyclopedia.com/doc/1P1-74226966.html [Accessed Jan 07, 2007]

Charles, D., Mcneill, M., McAlister, M., Black, M., Moore, A., Stringer, K., Kucklich, J., and Kerr, A. (2005). Player-centred Game Design: Player Modelling and Adaptive Digital Games. In DiGRA 2005 Conference: Changing Views – Worlds in Play.

Chase, W. G., and Simon, H. A. (1973). The Mind's Eye in Chess. In Visual information processing, Chase, W. G. (Ed.), New York: Academic Press, 215-281.

Cherry, E. C. (1953) Some Experiments on the Recognition of Speech, With One and With Two Ears. Journal of the Acoustical Society of America, 23, 915-919.

Chase, W., and Simon, H. (1973a) Perception in Chess. Cognitive Psychology, 4, 55-81.

Chiarenza, G. A., and Stagi, P. (2000) Neurophysiological Correlates of Perceptual-Motor Behavior in Down Syndrome. In Perceptual-Motor Behavior in Down Syndrome, Weeks, Chua, D. J., and Elliott, D. (Eds.), Human Kinetics, 321-347.

CHI Workshop (2010) Video games as research instrument. http://www.uclic.ucl.ac.uk/people/e.calvillo/ws_videogames [Accessed November 20, 2010]

Chisnell, D.E., Redish, J.C.G., Lee, A. (2006) New Heuristics for Understanding Older Adults as Web Users, Technical Communication, 53 (1), 39-59.

Choruma, T. (2007). The Forgotten tribe. Progression.

Christianson, S. A. (1992) Emotional Stress and Eyewitness Memory: A Critical Review. Psychological Bulletin, 112, 284-309.

Christina, K., Wolfgang, H., Jakob, L., Michael, H., Arjan, G., and Manfred, T. (2010) Using Heuristics to Evaluate the Overall User Experience of Video Games and Advanced Interaction Games. Evaluation User Experience in Games: Concepts and Methods, Bernhaupt, R. (Ed.), Springer, 233-256.

Chudacoff, H. P. (2007) Children at Play: An American History. In Children/United States/History, NYU Press.

Cifter, A. S., and Dong, H. (2010) Instruction Manual Usage: A Comparison of Younger People, Older People and People with Cognitive Disabilities. In Global Perspectives on Design Science Research: 5th International Conference, DESRIST 2010, St. Gallen, Switzerland, June 4-5, 2010, Proceedings, Winter, R., Zhao, J. L., and Aier, S. (Eds.), Springer, 6105, 410-425.

Clarke, D., and Duimering, P. R. (2006) How Computer Gamers Experience the Game Situation: A Behavioural Study. Computer in Entertainment, 4, 1-23.

Clarke, S. G., and Haworth, J. T. (1994) Flow Experience in the Daily Lives of Sixth Form College Students. British Journal of Psychology, 85, 511-523.

Clements, D. H. (1987) Longitudinal Study of the Effects of Logo Programming on Cognitive Abilities and Achievement. Journal of Educational Computing Research, 3, 73-94.

Coady, S. (2002) Is E-Learning Right for You? Business North (The Business News Source for Northern Minnesolo and Nothern Wisconsin), December 06, 2002. http://www.businessnorth.com/viewarticle.asp?articleid=486 [Accessed December 06, 2009]

Cohen, Y. Dekker, J., Hulskamp, A., Kousemaker, D., Olden, T., Taal, C., and Verspaget, W. (2007) Demor: Egoshooter for the Blind. In Space Time Play, Pias, C. (Ed.), Springer, 288-289.

Colas, S., Monmarche, N., Gaucher, P., and Slimane, M. (2008) Artificial Ants for the Optimization of Virtual Keyboard Arrangement for Disabled People. In Artificial Evolution: Eight International Conference, Evolution Artificielle, EA 2007 Tours, Monmarche, N. (Ed.), Springer, 87-99.

Coleman, G. W., Macaulay, C., and Newell, A. F. (2006) Listen to This - Using Ethnography to Inform the Design of Auditory Interfaces. Haptic and Audio Interaction Design: First International Workshop, HAID 2006, Glasgow, UK, August 31 - September 01, 2006: Proceedings, McGookin, D., and Brewster, S. (Eds.), Springer, 4129, 133-144.

Colman, A. M. (2001) A Dictionary of Psychology (originally published by Oxford Dictionary Press, 2001). http://www.encyclopedia.com/doc/1O87-dualtaskperformance.html. [Accessed June 01, 2007]

Collins, K. (2008) Game Sound: An Introduction to the History, Theory and Practice of Video Game Music and Sound Design. MIT Press.

Cowan, N. (1995) Attention and Memory: An Integrated Framework, Human Information Processing, Oxford University Press, US, 200-239.

Cox, D., Meyers, E., and Sinha, P. (2004) Contextually Evoked Object-Specific Responses in Human Visual Cortex, In American Association for the Advancement of Scientist (ASSS), 304 (5667), 115-117.

Creative Technology Limited (2002) EAX Advanced HD: Total Audio Immersion in PC Gaming. http://www.creative.com/soundblaster/technology/eax/welcome.aspx [Accessed November 02, 2006]

Crow, J., Javaux, D., and Rushby, J. (2000) Models and Mechanized Methods that Integrate Human Factor into Automation Design. International Conference on Human-Computer Interaction in Aeronautics: HCI-Aero, Cepadues-Editions, Toulouse, France, September 2000, Abbott, K., Speyer, J., and Boy, G. (Eds.), 163-168.

D

Darvishi, A., Munteanu, E., Guggiana, V., and Schauer, H. (1994) Automatic Impact Sound Generation for Using in Non-Visual Interfaces. The First Annual ACM Conference on Assistive Technologies - ASSETS'94, New York, USA, 100-106.

Davies, D. R., and Jones, D. M. (1982) Hearing and Noise. In The Body at Work: Biological Ergonomics, Singleton, W. T. (Ed.), CUP Achieve, 365-413.

Davies, D. R., and Parasuraman, R. (1982) The Psychology of Vigilance. London: Academic Press.

Dearden, R. F. (1976) Problems in Primary Education. Routledge.

Dede, C. (2005) Planning for Neomillennial Learning Styles: Implications for Investments in Technology and Faculty. Educating the Net Generation, Boulder, CO: EDUCASE Publishers, J. Oblinger and D. Oblinger (Eds.), 226-247.

De Groot, A. (1966) Perception and Memory Versus Thought: Some Old Ideas and Recent Findings. In Problem solving. B. Kleinmuntz (Ed.), NY: Wiley.

De Haan, K., Reed, W. M., and Kuwada, K. (2010) The Effect of Interactive with A Music Video Game on Second Language Vacabulary Recall. Language Learning and Technology, Chun, D., and Thompson, I. (Eds.), June 2010, 14 (2), 74-94.

Desurvire, H., Caplan, M., and Toth, J. A. (2004) Using Heuristics to Evaluate the Playability of Games. In CHI '04 Extended Abstracts on Human Factors in Computing Systems (Vienna, Austria, April 24-29, 2004), New York, NY, 1509-1512.

Desurvire, H., and Wiberg, C. (2009) Game Usability Heuristics (PLAY) for Evaluating and Designing Better Games: The Next Iteration. In Online Communities and Social Computing: Third International Conference, OCSC 2009, Held as Part of HCI International 2009, San Diego, CA, USA, July 19-24, 2009, Ozok, A. A., and Zaphiris, P. (Eds.), Springer, 557-566.

Desurvire, H., and Wiberg, C. (2010) User Experience Design for Inexperienced Gamers: GAP - Game Approachability Principles. In Evaluating User Experience in Games: Concepts and Methods. Bernhaupt, R. (Ed.), Springer, 131-148.

Deutsch, J. A., and Deutsch, D. (1963) Attention: Some Theoretical Considerations, Psychological Review, 70, 80-90.

Devore, S., and Shinn-Cunningham, B. G. (2003) Perceptual Consequences of Including Reverberation in Spatial Auditory Displays. In Proceedings of International Conference on Auditory Displays.

Digiplay (2004) Some Key Gaming Facts. http://www.digiplay.org.uk/facts.php [Accessed January 03, 2007]

Dillon, A. (2001) Beyond Usability: Process, Outcome and Affect in HCI. Canadian Journal of Information Sciences, 26 (4), 57-69.

Dondi, C., and Moretti, M. (2007). A Methodological Proposal for Learning Games Selection and Quality Assessment. British Journal of Education Technology, 38 (3), 502-512.

Drewes, T., Mynatt, E., and Gandy, M. (2000) An Audio Experience. In Proceedings of International Conference on Auditory Display, Atlanta, GA: USA.

Drewes, T. M., Mynatt, E. D., and Gandy, M. (2002) Sleuth: An Audio Experience. In ICAD2002, 2002.

Driskell, J. E., and Salas, E. (1996) Stress and Human Performance, Job Stress, Lawrence Erlbaum Associates.

Drullman, R., and Bronkhorst, A. W. (2000) Multichannel Speech Intelligibility and Talker Recognition Using Monaural, Binaural, and Three-Dimensional Auditory Presentation, J. Acoust. Soc. Am., 107, 2224- 2235.

Durkin, K. (2006) Game Playing and Adolescents' Development. In Playing video games: Motives, responses, and consequences, Vorderer, P., and Bryant, J. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 415-428.

Dyck, J., Pinelle, D., Brown, B., and Gutwin, C. (2003) Learning from Games: HCI Design Innovations in Entertainment Software. In The 2003 Conference on Graphics Interface, Halifax, Canada.

E

Eck, R. V. (2010) Gaming and Cognition: Theories and Practice from the Learning Sciences. IGI Global Snippet.

Edwards, A. D. N. (1988). Design of Auditory Interfaces for Visually Disabled Users, In Proceedings of the SIGCHI conference on Human Factors in Computing Systems, ACM, New York, USA, 83-88.

Edwards, A. D. (1989) Soundtrack: An Auditory Interface for Blind Users. In ACM SIGCHI Bulletin, New York: USA, 21 (1), 124.

Ekman, I., Lahti, J., Nummela, J., Lankoski, P., and Mayra, F. (2005) Designing Sound for a Pervasive Mobile Game. In ACE '05: Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology, 110-116.

Elen, R. (2001) Ambisonics: The Surround Alternative. In Proceedings of the Third Annual Surround Conference and Technology Showcase.

Elliot, A. J., and Dweck, C. S. (2005) Competence and Motivation: Competence as the Core of Achievement Motivation. In Handbook of Competence and Motivation, Elliot, A. J., and Dweck, C. S. (Ed), Guilford Press 2005, 3-14.

Entertainment Software Association, ESA. (2007) 2007 Essential Facts about the Computer and Video Game Industry. $http://www.theesa.com/facts/pdfs/ESA_EF_2007.pdf$ [Accessed June 10, 2008]

Erev, I., and Roth, A. E. (1998) Predicting How People Play Games: Reinforcement Learning in Experimental Games with Unique, Mixed Strategy Equilibria. The American Economic Review. 88, 848-881.

Eriksson, Y., and Gardenfors, D. (2004) Computer Games for Children with Visual Impairment. In Proceedings: 5th International Conference of Disability, Virtual Reality and Associated Technology, Oxford: UK, 78-86

Eskelinen, M. (2001) The Gaming Situation. Game Studies, 1(1).

Eysenck, M. W. (1985) Anxiety and Cognitive Task Performance. Personality and Individual Differences, 6, 579-586.

Eysenck, M. W., and Keane, M. T. (1996) Cognitive Psychology: A Student's Handbook (Third Edition). Psychology Press, UK.

F

Facer, K. (2001) Learners' out-of-school uses of computers, preliminary report from the InterActive Education: Teaching and Learning in the Information Age Project, Graduate School of Education, University of Bristol, www.interactiveeducation.ac.uk

Federoff, M. (2002) Heuristics and Usability Guidelines for the Creation and Evaluation of FUN in Video Games. Thesis at the University Graduate School of Indiana University, Dec 2002.

Feierabend, S., and Klingler, W. (2001) Children and Media 2000. PC/ Internet gain important. Media perspektiven 7/2001, 345-357.

Felicia, P. (2009) Digital Games in Schools. Kearney, C. (Ed.), European Schoolnet: Belgium.
http://games.eun.org/upload/gis_handbook_en.pdf [Accessed Jan 18, 2011]

Finkelman, J. M., Zeitlin, L. R., Romo, R. A., Friend, M. A., and Brown, L. S. (1979) Conjoint Effect of Physical Stress and Noise Stress on Information Processing Performance and Cardiac Response. Human Factors, 21, 1-6.

Fisher, G. H. (1963) Letters: Feeling for Colour. New Scientist, Reed Business Information, 18 (No. 335), April 18, 1963. 165.

Federal Aviation Administration (2008) Human Factors. In Instrument Flying Handbook. Skyhorse Publishing Inc.

Feinberg S., and Murphy M. (2000) Applying Cognitive Load Theory to the Design of Web-Based Instruction. In Proceedings of the IEEE Professional Communication Society International Professional Communication Conference. Cambridge, MA. Piscataway, NJ: IEEE.

Foundation for Research and Technology - Hellas Institute of Computer Science, FORTH-ICS (2003-2006) Universally Accessible Games. http://www.ics.forth.gr/hci/ua-games/ [Accessed March 23, 2008]

Friberg, J., and Gardenfors, D. (2004) Audio games: New Perspectives on Game Audio. In Proceedings of the 2004 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology, ACM New York, USA, 148-154.

Fu, F., Su, R., and Yu, S. (2009) EGameFlow: A Scale to Measure Learners' Enjoyment of E-Learning Games. Computer and Education, Elsevier Science Ltd: Oxford, UK, 52 (1), 101-112.

Fullerton, T., Swain, C., Swain, C., Hoffman, S. (2004) Game Design Workshop: Designing, Prototyping, and Playtesting Games, Focal Press.

Furth, B. (2008) Encyclopedia of Multimedia. Springer.

G

Gackenbach, J. (2010) Video Game Play and Dreams: What are the Important Questions? In the International Association for the Study of Dreams, 9th Annual Psiber Dreaming Conference, September 26 - October 10, 2010. $http://academic.macewan.ca/gackenbachj/2010/07/29/research-status-update-and-dreams-for-comment/$ [Accessed March 10, 2011]

Gaillard, A. W. K. (2001) Stress, Workload and, Fatigue as Three Biobehavioral States: A General Overview. In Stress, Workload, and Fatigue, Hancock, P. A., and Desmond, P. A. (Eds.), Mahwah, NJ: Erlbaum, 623-639.

Gaillard, A. W. K. (2003a) Fatigue Assessment and Performance Protection. In Operator Functional State: The Assessment and Prediction of Human performance Degradation in Complex Tasks, Hockey, G. R. J., Gaillard, A. W. K., and Burov, O. (Eds.), ISO Press: Amsterdamn, 24-35.

Gaillard, A. W. K. (2003b) Stress, Productivity, and Health. Nieuwezijds: Amsterdamn.

Gaillard, A. W. K. (2007) Concentration, Stress and Performance. Performance under stress, Hancock, P. A., and Szalma, J. L. (Eds.), Ashgate Publishing, Ltd.

Gaillard, A. W. K. (2008) Concentration, Stress and Performance. In Performance Under Stress, Hancock, P. A., and Szalma, J. L. (Eds.), Ashgate Publishing, Ltd., 59-72.

Galarneau, L., and Zibit, M. (2006) Online Games for 21st Century Skills. In Games and simulations in online learning: Research and development, D. Gibson, C. Aldrich and M. Prensky (Eds.), Idea Group Inc (IGI), 59-88.

Galat, J. (2010) Coaching Youth Football. Human Kinetics.

Galitz, W. O. (2007) The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques. John Wiley and Sons.

Gardner, B., and Martin, K. (1994) HRTF Measurements of KEMAR Dummy Head Microphone. Technnical Report 280, MIT Media Lab, May 1994.

Gardner, H. (1985) The Mind's New Science. New York: Basic Book.

Game Accessibility Special Interest Group (GA-SIG, 2004) Accessibility in games: Motivations and approaches. $http://www.igda.org/accessibility/IGDA_Accessibility_WhiteP$

Gaser, C., and Schlaug, G. (2003) Brain Structures Differ Between Musicians and Non-Musicians. The Journal of Neuroscience, 23 (27), 9240-9245.

Gaudy, T., Natkin, S., Archambault, D. (2006) Classiffcation Des Jeux Sonores Selon Leur Type De Jouanilite, Handicap 2006 Conference.

Gaudy, T., Natkin, S., and Archambault, D. (2009) Pyvox 2: An Audio Game Accessible to Visual Impaired People Playable Without Visual Nor Verbal Instructions. In Transactions on Edutainment II: Volume 2, Pan, Z., Rhabili, A. E., Cheok, A. D., and Muller, W. (Eds.), Springer-Verlag: Berlin, Heidelberg, 5660, 176-186.

Gaver, W. W. (1986) Auditory icons: Using sound in computer interfaces. Human Computer Interaction, 2, 167-177.

Gaver, W. (1989) The SonicFinder: An Interface That Uses Auditory Icons, Human Computer Interaction, 4 (1), 87-94

Gaver, W. W. (1997) Auditory Interfaces. Handbook of Human-Computer Interaction. Helander, M., Landauer, T. K., and Prabhu, P. V. (Eds.), Elsevier, 1003-1038.

Gaver, W., Smith, R. and O'Shea, T. (1991) Effective Sounds in Complex Systems: The ARKola Simulation. In Reaching through technology CHI'91, S. Robertson, G. Olson and J. Olson (Eds.), Reading MA: Addison-Wesley, 85-90.

Gee, J. P. (2005) Learning by Design Good Video Games as Learning Machines. E-Learning, Common Ground Publishing Pty Ltd., 2, 5-16.

Gerzon, M. (1985) Ambisonics in Multichannel Broadcasting and Video. Journal of the Audio Engineering Society, 33 (11), 859-871.

Gevins, A., and Smith, M. E. (1999) Detecting Transient Cognitive Impairment with EEG Pattern Recognition Methods. Aviation, Space and Environmental Medicine, 70, 1018-1024.

GMA games (2003) Shades of Doom. http://www.gmagames.com/sod100dl.html [Accessed July 17, 2010]

Gomes, L. M. P., Martinho-Pimenta, A. J. F., and Castelo-Branco, N. A. A. (1999) Effects of Occupational Exposure to Low Frequency Noise on Cognition. Aviation, Space and Environmental Medicine, 70, A115-A118.

Gookin, D. (2007) Find Gold in Windows Vista. John Wiley and Sons.

Gottlieb, B. H. (1997) Coping with Chronic Stress. Adaptability (Psychology), Springer.

Graetz, J. M. (1981) The Origin of Spacewar. Creative Computing magazine, August 1981.

Grammenos, D. (1989-2007) Human-Computer Interaction Laboratory. http://ua-games.gr/index.html [Accessed August 02, 2010]

Grammenos, D., Savidis, A., Stephanidis C. (2005) UA-Chess: A Universally Accessible Board Game. In Proceedings of the 3rd International Conference on Universal Access in Human-Computer Interaction. G. Salvendy (ed.). Las Vegas, Nevada, USA, July 2005. Lawrence Erlbaum.

Grammenos, D., Savidis, A., and Stephanidis, C. (2007) Unified Design of Universally Accessible Games. In Universal Access in Human-Computer Interaction: 4th International Conference on Universal Access in Human-Computer Interaction, UAHCI 2007, Beijing, China, July 22-27, 2007, Stephanidis, C. (Ed.), Springer, 607-616.

Gray, W. D., Young, R. M., and Kirschenbaum, S. S. (1997) Introduction to this special issue on cognitive architectures and human-computer interaction. Human-Computer Interaction, 12, 301-309.

Greenfield, P. M. (1994). Effects of Interactive Entertainment Technologies on Development. Journal of Applied Developmental Psychology, 15 (1), 3-11.

Greenfield, P., Brannon, D., and Lohr, D. (1994) Two-Dimensional Representation of Movement Through Three-Dimensional Space: The Role of Video

Game Expertise. In Journal of Applied Developmental Psychology, 15 (1), 87-103.

Greenfield, P. M,, Camaioni, L., Ercolani, P., Weiss, L., Lauber, B. A., and Perruccini, P. (1994) Cognitive Socialization by Computer Games in Two Cultures: Inductive Discovery or Mastery of Iconic Code? Journal of Applied Developmental Psychology, 15, 59-85.

Greenfield, P. M., and Subrahmanyam, K. (1994) Effect of Video Game Practice on Spatial Skills in Girls and Boys. J. Appl. Develop. Psychol. 15(1), 13-32.

Gregor, P., and Newell, A. F. (2001) Designing for Dynamic Diversity - Making Accessible Interfaces for Older People. In Proceedings of 2001 EC/NSF Workshop on Universal Accessibility of Ubiquitous Computing: Providing for the Elderly, Jorge, J., Heller, R., and Guedj, R. (Eds.), ACM Press, 22-25 May 2001 Alcacer do Sal, Portugal, 90-92.

Gregory, R. L. (1997) Eye and Brain: The Psychology of Seeing. Princeton University Press, Fifth Edition.

Grodal, T. (2000) Video Games and the Pleasure of Control. In Media Entertainment: The Psychology of its Appeal, Zillmann, D., and Vorderer, P. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 197-212.

Grolier, Inc. (1994) Academic American Encyclopedia. Encyclopedias and dictionaries, Grolier Academic Reference.

Gruber, A. (1964) Sensory Alternation and Performance in a Vigilance Task. Human Factors, 6, 3-12.

Gunderson, J. (2003) Universally Accessible Web Resources: Designing for People with Disabilities. In The Internet Encyclopedia, Bidgoli, H. (Ed.), John Wiley and Sons, 477-493.

Gunter, B. (1998) The Effects of Video Games on Children: The Myth Unmasked. Video Games and Children, Continuum International Publishing Group.

Gurubatham, M. R. (2005) Cognition, Culture and Effective E-Paraxis Guiding Principles: Theoretical Roots for E-Culture. In E-Training Practices for Professional Organizations: IFIP TC3/WG3.3 Fifth Working Conference on eTRAIN Practices for Professional Organizations (eTRAIN 2003), July 7-11, 2003, Pori: Finland, 167, Nicholson, P., Thompson, J. B., and Rouhonen, M. (Eds.), Springer, 121-128.

H

Habgood, J., and Overmars, M. (2006) The Game Maker's Apprentice: Game Development for Beginners. Apress.

Habour, J. S. (2002) Microsoft Visual Basic Game Programming with DirectX. Thomson Court Technology (1100 pages).

Hampson, P. J., and Morris, P. E. (1996) Understanding Cognition. Cambridge: Blackwell Publishers, Inc.

Hancock, P. A., and Desmond, P. A. (2001) Stress, Workload, and Fatigue. Lawrence Erlbaum Associates.

Hanin, Y. L. (2000) Emotions in Sport, Champaign, IL: Human Kinetics, 80.

Hartley, L. R., and Adams, R. G. (1974) Effect of Noise on the Stroop Test. Journal of Experimental Psychology, 102, 62 - 66.

Hartmann, T., and Klimmt, C. (2006) The Influence of Personality Factors on Computer Game Choice. In Playing video games: Motives, responses, and consequences, P. Vorderer and J. Bryant (Eds.), Mahwah: Lawrence Erlbaum Associates, 115-133.

Hartson, H. R., and Hix, D., (1989) Toward Empirically Derived Methodologies and Tools for Human-Computer Interface Development, International Journal of Man-Machine Studies, 31,477-494.

Hassenzahl, M., Tractinsky, N. (2006) User Experience - A Research Agenda. In Behavioral and Information Technology, 25 (2), 91-97.

Hawley, M. L., and Litovsky, R. Y., and Culling, J. (2000) The Cocktail Party Problem with Our Types of Maskers: Speech, Time-Reversed Speech, Speech-Shaped Noise, or Modulated Speech-Shaped Noise. In Proceedings of MidWinter Meeting of the Association for Research in Otolaryngology, St. Petersberg Beach, FL.

Harlow, S. D. (1985) Humanistic Perspectives on Computers in the School. Education, Data Processing and Social Aspects, Haworth Press.

Heathcote, A., Brown, S. and Mewhort, D. J. K. (2000) The Power Law repealed: The case for an Exponential Law of Practice. Psychonomic Bulletin and Review, 7, 185-207.

Helander, M., Landauer, T.K. and Prabhu, P., (1997) (Eds.), Handbook of Human-Computer Interaction, Elsevier Science BV, (ISBN 0 a.44 81862 6), 813-824.

Herman, L. (1997) Phoenix: The Fall and Rise of Videogames, Rolenta Press, Union, New Jersey.

Herman, L. (2008) The Video Game Explosion: A History from PONG to Playstation and Beyond, Wolf, M. J. P. (Ed), ABC-CLIO Publication, 143-150.

Herz, J. C. (1997) Joystick Nation. Little, Brown and Company, 27.

Herzberg, F., Mausner, B., and Snyderman, B. B. (1959). The motivation to work. New York: John Wiley and Sons.

Hicks, R. (2007) Blindness. $http://www.bbc.co.uk/health/physical_health/conditions/blindness1.shtml$ [Accessed September 12, 2010]

Hillier, A., Alexander, J. K., and Beversdorf, D. Q. (2006) The Effect of Auditory Stressors on Cognitive Exibility. Neurocase Psychology Press, 12 (4), 228-231.

Hinds, P. (1999) Some Cognitive Costs of Video. Media Psychology, 1, 283-311.

Hockey, G. R. T. (1979) Stress and the Cognitive Components of Skilled Performance. In Human Stress and cognition: An information processing approach, V. Hamilton and D. M. Warburton (Eds.), New York: John Wiley and Sons, 141-177.

Hockey, R., Gaillard, W. K. A., and Coles, M. G. H. (1986) Energetics and Human Information Processing. Human Information Processing, Physiological aspects and Congresses, Springer Publication.

Holland, P. C., and Gallagher, M. (2004) Amyglada-Frontal Interaction and Reward Expectancy. In Current Opinion in Neurobiology. Science Direct, 14, 148-155.

Honeybourne, J., Hill, M., and Moors, H. (2000) Advanced Physical Education and Sport for AS-level. Physical Education and Training, Nelson Thornes publication.

Hsiao, H. C. (2007) A Brief Review of Digital Games and Learning. In The First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning, Jhongli: Taiwan.

Hunt, R. R., and Ellis, H. C. (1999) Fundamentals of Cognitive Psychology, Sixth Edition.

Hudlicka, E., and Zacharias, G. (2005) Requirements and Approaches for Modeling Individuals Within Organizational Stimulations. Organizational Stimulation, Rouse, W. B., and Boff, K. R. (Eds.), John Wiley and Sons, 44, 79-137.

Hung, T. L, and Adams, R. (2010) Creating and Evaluating Accessible Sound-Only Games. Doctoral Consortium, NordiChi, Reykjavik: Iceland, 16-20 October, 2010. Accessed on Jan 08, 2011 http://sites.google.com/site/nordichi2010dc/participants

Huppert, F. (2003) Designing for Older Users. In Inclusive design: design for the whole population, Clarkson, J., Coleman, R., Keates, S., and Lebbon, C. (Eds.), Springer, 30-49.

Hutchings, P. (2004) The Horror Film. Horror films/ History and Criticism, Harlow, England; New York: Pearson Longman.

I

IGDA (2004) Accessibility in Games: Motivations and Approaches. International Game Developers Association White Paper, $http://archives.igda.org/accessibility/IGDA_Accessibility_WhitePaper.pdf$ [Accessed August 27, 2010]

IGDA (2005) Accessibility in Games: Motivations and Approaches. International Game Developers Association White Paper. $http://archives.igda.org/casual/IGDA_CasualGames_Whitepaper_2005.pdf$ [Accessed August 25, 2010]

IGDA (2005) International game developers association. http://www.igda.org.

Ilmonen, T., and Kontkanen, J. (2002) Software Architecture for Multimodal User Input - FLUID. In the Proceedings of the Seventh ERCIM Workshop on User Interfaces for All, Chantilly, France, 223-242.

Imrie, R., and Hall, P. (2001) Inclusive Design: Designing and Developing Accessible Environments. Spon Press: London and New York.

Inkpen, K. (1997) Three Important Research Agendas for Educational Multimedia: Learning, Children, and Gender. In Proceedings Of Educational MultiMedia '97 Calgary", AB, June 1997, 521-526.

Interactive Entertainment Association of Australia (IEAA, 2005) Top Ten Industry Facts. $http://www.ieaa.com.au/research/top_10_industry_facts.html$ [Accessed June 10, 2008]

Isbister, K., and Schaffer, N. (2008) Game Usability: Advancing the Player Experience. Morgan Kaufmann.

Ivory, J. D., and Kalyanaraman, S. (2007) The Effects of Technological Advancement and Violent Content in Video Games on Players' Feelings of Presence, Involvement, Physiological Arousal, and Agression. In Journal of Communication, International Communication Association, 57, 532-555.

Iwarsson, S., and Stahl, A. (2003) Accessibility, Usability, and Universal Design - Positing and Definition of Concepts Describing Person-Environemtn Relationships. Assistive Technology: Shaping the Future: AAATE'03, Craddock, G. M. (Ed.), IOS Press, 11, 687-700.

J

Jacoby, D. B., and Youngson, R. M. (2004) Encyclopedia of Family Health. Marshall Cavendish.

James, W. (1890) Principles of Psychology, New York: Holt

Jeong, S. (2007) Suggestion of Methods for Understanding User's Emotional Changes While Using a Product. In "Human Interface and the Management of Information: Methods, techniques and tools in information design, Smith, M. J. (Ed.), Springer, 59-67.

Jones, D. (1989). The Sonic Interface. In Work with Computers: Organizational, Management, Stress and health aspects, M. Smith and G. Salvendy (Eds.), Amsterdam: Elsevier Science publishers.

Johnson, M., Kulkarni, S., Ray, A., Carff, R., and Bradshaw, J. M. (2005). An Adaptive Multi-Agent Framework for Augmented Cognition. HCII vol. 11. Foundations of Augmented Cognition: Mira Digital Publishing.

Jones, R. M., Lebiere, C., and Crossman, J. A. (2007) Comparing modeling idioms in ACT-R and Soar. In Proceedings of the Eighth International Conference on Cognitive Modeling, Ann Arbor: MI.

Jorgensen, A. H. (2004) Marrying HCI/Usability and Computer Games: A Preliminary Look. In Proceedings of NordiCHI 2004, doi:10.1145/1028014.1028078.

Josephs, R. A., Silvera, D. H., and Giesler, R. B. (1996) The Learning Curve as a Metocognitive Tool. Journal of Experimental Psychology: Learning, Memory and Cognition, 22, 510-524.

Juul, J. (2005) Half-Real: Video Games Between Real Rules and Fictional Worlds. Cambridge: The MIT Press.

K

Kahneman, D. (1973) Attention and Effort. Prentice-Hall: Englewood Cliffs, N. J.

Kalat, J. W. (2008) Biological Psychology. Cengage Learning: Tenth Edition.

Kalyuga, S. (1997). Cognitive Load Effects and Design of Computer Based Instruction. In Proceedings of the Second ACM International Conference on Digital Libraries, Philadelphia, Pennsylvania, U. S. A., 260.

Kalyuga, S. (2000) When Using Sound with a Text or Picture is Not Beneficial for Learning. In Australian journal of Educational Technology, 16 (2), 161-172.

Kalyuga, M. (2007) Enhancing Instructional Efficiency of Interactive E-Learning Environments: A Cognitive Load Perspective. In Educational Psychology Review 19, 387-399.

Kalyuga, S., Chandler, P., and Sweller, J. (2000) Incorporating Learner Experience into the Design of Multimedia Instruction. Journal of Educational Psychology, 92, 126-136.

Kandel, E. R., Schwartz, J. H., Jessell, T. M. (2000) The Neural Basis of Cognition. In Principles of neural science, McGraw-Hill Professional, 317-381.

Kippen, J. (1988) The Tabla of Lucknow. Cambridge University Press.

Karasek, R. (1998) Demand/ Control Model: A Social, Emotional, and Psychological Approach to Stress Risk and Active Behaviour Development. In Encyclopaedia of Occupational Health and Safety, Stellman, J. M. (Ed.), International Labour Organization, 34.6-34.13.

Karousos, N., Papaloukas, S., Kostaras, N., Xenos, M., Tzagarakis, M., and Karacapilidis, N. (2010) Usability Evaluation of Web-Based Collaboration Support Systems: The Case of CoPe it! In Knowledge Management, Information Systems, E-Learning, and Sustainability Research: Third World Summit on the Knowledge Society, WSKS 2010, Corfu, Greece, September 22-24, 2010, Proceedings, Part 1, Lytras, M. D., De Pablos, P. O., Ziderman, A., Roulstone, A., Maurer, H., and Imber, J. B. (Eds.), Springer, 111, 248-258.

Kaufmann-Hayoz, R., Battig, C., Bruppacher, S., Defila, R., Giulio, A. D., Flury-Kleubler, P., Friederich, U., Garbely, M., Gutscher, H., Jaggi, C., Jegen, M., Mosler, H., Muller, A., North, N., Ulli-Beer, S., and Wichtermann, J. (2001) A Typology of Tools for Building Sustainability Strategy. In Changing Things - Moving People: Strategies for Promoting Sustainable Development at the Local Level, Kaufmann-Hayoz, R., and Gutscher, H. (Eds.), Birkhauser, 47-108.

Keates, S., and Clarkson, P. J. (2003) Countering Design Exclusion: An Introduction to Inclusive Design. Springer.

Keates, S., and Clarkson, J. (2003) Design Exclusion. In Inclusive design, Clarkson, J., Coleman, R., Keates, S., and Lebbon, C. (Eds.), Springer, 88-107.

Keates, S., Kozloski, J., and Varker, P. (2009) Cognitive Impairments, HCI and Daily Living. In Universal Access in Human-Computer Interaction, Addressing Diversity, Springer, 5614, 366-374.

Keates, S., and Robinson, P. (1997) The Role of User Modeling in Rehabilitation Robotics. In Proceedings of the Fifth International Conference on Rehabilitation Robotics (ICORR 97), Bath, UK, 75-78.

Kefauver, A. P. (2001). Microphone technique: Stereo techniques (Binaural systems - Chapter 4). The audio recording handbook. A-R Editions, Inc.

Keller, J. M. (2009) Motivational Design for Learning and Performance: The ARCS Model Approach. Springer.

Kent, S. L. (2000) The First Quarter: A 25-Year History of Video Games. Bothell, WA: BWD Press.

Kerlow, I. V. (2003) The Art of 3D Computer Animation and Effects. John Wiley and Sons.

Kerr, A. (2006) The Business of Making Games. In Understanding Digital Games, Chapter in Rutter, J. and Bryce, J. (Eds.), Sage Publications: London.

Kersten-Tsikalkina, M., Bekker, M.M. (2001) Evaluating Usability and Fun of Children's Products. In Proceedings of the International Conference on Affective Human Factors Design, Singapore, Asia. M.G. Helander, H.M. Khalid, M.P. Tham (Eds.), London: Asean Academic Press, 450-457.

Kestenbaum, G. I., and Weinstein, L. (1985) Personality, Psychopathology, and Developmental Issues in Male Adolescent Video Game Use. Journal of the American Academy of Child Psychiatry, 24, 208-212.

Kickmeier-Rust, M. D., and Albert, D. (2010) Personalized Support, Guidance, and Feedback by Embedded Assessment and Reasoning: What We Can Learn from Educational Computer Games. In Human-Computer Interaction: Second IFIP TC 13 Symposium, HCIS 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-24, 2010, Forbrig, P., Paterno, F., and Pejtersen, A. M. (Eds.), Springer, 332, 142-151.

Kickmeier-Rust, M. D., Peirce, N., Conlan, O., Schwarz, D., Verpoorten, D., and Albert, D. (2007) Immersive Digital Games: The Interfaces for Next-Generation E-learning? In Universal Access in Human-Computer Interaction: Forth International Conference on Universal Access in Human-Computer Interaction, UAHCI 2007, held as part of HCI international 2007", Stephanidis, C. (Ed), Springer, Beijing, China, 647-656.

Kiili, K. (2005) Content Creation Challenges and Flow Experience in Education Games: The IT-Emperor Case. The Internet and Higher Education, 8(3), 183-198.

Kim, I. (2006) 3D Interactive Computer Games as a Pedagogical Tool. In Interactive Technologies and Sociotechnical SystemsL 12th International Conference, VSMM 2006, Xi'an, China, October 18-20, 2006, Springer, 4270, 536-544.

King, L. (2002) Introduction. In Game on: The history and culture of video games, L. King (Ed.), New York, NY: Universe Publishing, 8-19.

King, M., Stanley, G., Burrows, and G. D. (1987) Stress: Theory and Practice. Grune and Stratton.

Kirmeyer, S. (1988) Coping with Competing Demands: Interruption and the Type a Pattern. Journal of Applied Psychology, 73, 4, 621-629.

Kirsh, D. (2000) A Few Thoughts on Cognitive Overload. Intellectica, 30, 19-51.

Kitsana, K., and Innet, S. (2007) A HCI Keyboard Layout Design for Blind people. In International Workshop on Advaced Image Technology, Bangkok, 949-953.

Klasen, M., Zvyagintsev, M., Weber, R., Mathiak, K. A., and Mathiak, K. (2008) Think Aloud During fMRI: Neuronal Correlates of Subjective Experience in Video Games. Fun n' Games, Markopoulos, P., De Ruyter, B., and Ljsselsteijin, W. (Eds.), Springer, 5294, 132-138.

Kleitman, N. (1963). Sleep and Wakefulness. Chicago: University of Chicago Press.

Klevjer, R. (2001) Computer Game Aesthetics and Media Studies. In the Fifteen Nordic Conference on Media and Communication Research, Reykjavik, Iceland, August 11- 13, 2001. http://www.uib.no/people/smkrk/docs/klevjerpaper 2001.htm [Accessed February 12, 2007]

Klimmt, C., Blake, C., Hefner, D., Vorderer, P., and Roth, C. (2009) Player Performance, Satisfaction, and Video Game Enjoyment. In Entertainment Computing: 8th International Conference, ICEC 2009, Paris, France, September 3-5, 2009, Natkin, S., and Dupire, J. (Eds.), Springer, 5709, 1-12.

Klimmt, C., and Hartmann, T. (2006) Effectance, Self-Efficacy, and the Motivation to Play Video Games. In Playing Video Games: Motives, Responses and Consequences, Vorderer, P., and Bryant, J. (Eds.), Routledge, 133-144.

Kline, S., N., Witheford, D., and DePeuter, G. (2003) Digital Play. The Interaction of Technology, Culture, and Marketing. Montreal and Kingston: McGill-Queen's University Press.

Klug, G.C., and Schell, J. (2006) Why People Play Games: An Industry Perspective. Playing Video Games: Motives, Responses, and Consequences, Vorderer, P., and Bryant, J. (Eds.), Routledge, 91-100.

Kolers, P. A. (1976) Reading a Year Later. Journal of Experimental Psychology: Human Learning and Memory, 2, 554-565.

Kolodny, L. (2006) Global Video Game Market Set to Explode. BusinessWeek. $http://www.businessweek.com/innovate/content/jun2006/id20060623_163211.htm?chan = innovation_game + room_top + stories$ [Accessed January 05, 2007]

Konar, A., Jain, L. C., and Pedrycz, W. (2005) Cognitive Engineering: A Distributed Approach to Machine Intelligence, Springer.

Koopman, P. L., and Wierdsma, A. F. M. (2000) Participative Management. In Personnel Psychology, Second edition of Handbook of Work and Organizational Psychology, Drenth, P. J. D., Thierry, H., and De Wolff, C. J., 297-317.

Korhonen, H., Holm, J., and Heikkinen, M. (2007) Utilising Sound Effects in Mobile User Interface Design. In Human-Computer Interaction, INTERACT 2007: 11th IFIP TC 13 International Conference, Rio de Janeiro, Brazil, September 2007, Baranauskas, C. (Ed.), Springer, 283-296.

Korhonen H., Koivisto E.M.I. (2006) Playability Heuristics for Mobile Games. In Proceedings of Eight International Conference on Human-Computer Interaction with Mobile Devices and Services", MobileHCI'06, ACM Press, 9-16.

Koster, R. (2005) Theory of Fun for Game Design. Paraglyph Press, Scottdale: AZ.

Krane, V. (2006) Individual Zones of Optimal Functioning. In Encyclopedia of International Sports Studies, Bartlett, R., Gratton, C., and Rolf, C. 657-659.

Krippendorff, K. (1989) On the Essential Contexts of Artifacts or on the Proposition That Design Is Making Sense (Of Things), Design Issues, 5 (2), (Spring 1989), 9-39.

Kristiansen, E. (2008) Designing Innovative Video Games. Creating Experiences in the Experience Economy, Sundbo, J., and Darmer, P. (Eds.), Edward Elgar Publishing, 33-59

L

L'abate, L., and Bryson, C. H. (1994) A Theory of Personality Development. John Wiley and Sons.

Ladd, B. C., and Jenkins, C. J. (2010) Introductory Programming with Simple Games: Using Java and the Freely Available Networked Game Engine. John Wiley and Sons.

Lally, E. (2002) At Home with Computers. Berg Publisher.

Langdon, F. J. (1985) Noise Annoyance. In Tempest W, editor. The Noise Handbook, London, England, Academic Press, 143-176.

Larkin, J., McDermott, J., Simon, D., and Simon, H. (1980) Models of competence in solving physics problems. Cognitive Science, 4, 317-348.

Larsson, P, Vstfjll, D, and Kleiner, M. (2001) Ecological Acoustics and the Multimodal Perception of Rooms: Real and Unreal Experiences of Auditory-Visual Virtual Environments. In Proceedings of ICAD, Helsinki.

Laitinen, S. (2006) Do Usability Expert Evaluation and Test Provide Novel and Useful Data for Game Development? Journal of Usability Studies.

Laszlo, J., and Polya, T. (2002) The Role of the Narrative Perspective in the Cognitive-Cultural Context. Perspective and Perspectivation in Discourse, Graumann, C. F., and Kallmeyer, W. (Eds.), John Benjamins Publishing Company, 9, 375-387.

Laurel, B. (1991) Computers as Theater. Reading, MA: Addison-Wesley. Law, R., and Sweller, J. (2005). The modality principle in multimedia learning (Chapter 9). The Cambridge Handbook of Multimedia Learning, Cambridge University Press, 147-158.

Lawrence, C. (2006) Take a Load Off: Cognitive Consideration for Game Design. In ACM International Conference Proceeding Series, Perth, Australia, 207, 91-95.

Lawrence, V., Houghton, S., Tannock, R., Douglas, G., Durkin, K. and Whiting, K. (2002) ADHD Outside the Laboratory: Boys' Executive Function Performance on Tasks in Videogame Play and on a Visit to the Zoo. Journal of Abnormal Child Psychology, 30, 447-462.

Lee, K. M., and Peng, W. (2006) What Do We Know About Social and Psychological Effects of Computer Games? A Comprehensive Review of the Current Literature. In Playing video games: Motives, responses, and consequences. Vorderer, P., and Bryant, J. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 325-246.

LeCompte, D. (1999) Seven, Plus or Minus Two, Is Too Much to Bear. Three (or Fewer) is the Real Magic Number. In Proceedings of the Human Factors and Ergonomics Society, 289-292.

Lewis, J. L. (1970) Semantic Processing of Unattended Messages Using Dichotic Listening, Journal of Experimental Psychology, 85, 225-228.

Libby. H. (2002) The Role of Usability Research in Designing Children's Computer Products - Developing Educational Computer Games, EDLF 703-1 Interactive Technology, (www.people.virginia.edu).

Lieberman, D. A. (1998). Health education video games for children and adolescents: Theory, desgn and research findings. Paper presented at the annual meeting of the International Communication Association, Jerusalem.

Lieberman, D. A. (2006) What can we learn from playing interactive games? In "Playing video games: motives, responses, and consequences", Vordered, P., and Bryant, J. (Eds.), Routledge, 379-398.

Lin, C., and Liu, E. (2010) A Comparison Between Drill-Based and Game-Based Typing Software. Transactions on Edutainment III, Pan, Z., Cheok, A. D., Muller, W., and Chang, M. (Eds.), 48-48.

Littlefield, R. S., and Sellnow, T. L. (1992) Assessing Competition and Stress: The Perceived Effect of Tournament Atmosphere on Students and Coaches. National Forensic Journal, Spring 1992, 10(1), 1-10.

Locke, E. A., and Latham, G. P. (1990) A Theory of Goal Setting and Task Performance, Englewood Cliffs, NJ: Prentice Hall.

Loftus, E. F., and Schooler, J. W. (1978) Information Processing Conceptualization of Human Cognition: Past, Present, and Future. In Information and Behaviour by Brent D. Ruben, Transaction publisher, 225-250.

Logan, G. D. (1979) On the Use of a Concurrent Memory Load to Measure Attention and Automaticity. Journal of Experimental Psychology: Human Perception and Performance, 5, 189-207.

Logan, G. D. (1988) Toward an Instance Theory of Automatization. Psychological Review, 95, 492-527.

Loh, C. S. (2008) Confronting the Dark Side of Video Games. Games: Purpose and Potential in Education, Miller, C. T. (Ed.), Springer, 185-218.

Loveless, N. E. (1957) Signal Detection with Simultaneous Visual and Auditory Presentation. FPRC Report No. 1027.

Lowe, D. (1982) History of Bourgeois Perception. Brighton: Harvester Press.

Lowood, H. (2008) Found Technology: Players as Innovators in the Making of Machinima. In Digital, Youth, Innovation, and the Unexpected, McPherson, T. (Ed.), MIT Press, 165-196.

Lucht, M., Domagk, S., and Mohring, M. (2010) Exer-Learning Games: Transferring Hopcotch from the Schoolyard to the Classroom. In Artificial Intelligence in Theory and Practice III: Third IFIP TC 12 International Conference on Artificial Intelligence, IFIP AI 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-24, 2010, Bramer, M. (Ed.), Springer, 331, 25-34.

M

McAdams, S., and Drake, C. (2004) Auditory Perception and Cognition. Steven's Handbook of Experimental Psychology, Sensation and Perception. Pashler, H., and Yantis, S. (eds.), John Wiley and Sons, 397-452.

Mace, N. L. (2005) Teaching Dementia Care: Skill and Understanding, Education, Nursing, JHU Press.

MacGregor, J. N. (1987) Short-Term Memory Capacity: Limitation or Optimization? Psychological Review, 94 (1), 107-108.

MacIntyre, P. D. (2002) Motivation, Anxiety and Emotion in Second Language Acquisition. In Individual differences and instructed language learning, Robinson, P. (Ed.), John Benjamins Publishing Company, 45-68.

Mackworth, N. H. (1950) Researches on the Measurement of Human Performance, Medical Research Council Special Report 268, London HMSO.

MacLeod, C. M., and Dunbar, K. (1988) Training and Stroop-like interference: Evidence for a continuum ofautomatieity. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14, 126-135.

Magennis, M., Gallagher, B., Wood, J., Arias, E. C., Sevilla, J. M., Gladstone, K., Graupp, H., Gutierrez, T., Avizzano, C., and Bergamasco, M. (2003) GRAB - A New Haptic and Audio Virtual Environment Enabling Vision Impaired People to Access the Three-Dimensional Computer Graphic World. In Assistive technology - Shaping the future, G. Craddock et al. (Eds.), IOS Press, 471-480.

Malone, T. W. (1980) What makes things fun to learn? A Study of intrinsically motivating computer games. Technical Report CIS-7, Xerox PARC, Palo Alto.

Malone, T. (1981) Towards a Theory of Intrinsically Motivating Instruction. Cognitive Science, 4, 333-369.

Malone, T.W. (1982) Heuristics for Designing Enjoyable User Interfaces: Lessons from Computer Games. In Human Factors in Computing Systems, Thomas, J. C., and Schneider, M. L. (Eds.), Norwood, NJ: Ablex Publishing Corporation.

Malone, T. W. (1984) Heuristics for Designing Enjoyable User Interface: Lessons from Computer Games. Human Factors in Computer Systems, Thomas, J. c., and Schneider, M. L. (Eds.), Intellect Books, 1-12.

Malone, T. W., and Lepper, M. R. (1987) Making Learning Fun. A Taxonomy of Intrinsic Motivation for Learning. In Aptitude learning and instruction III: Conactive and affective process analyses: Hillsdale, R. E. Snow and M. J. Farr (Eds.), NJ: Erlbaum.

Mandler, J. (1984) Stories, Scripts, and Scenes: Aspects of Schemata Theory. Hillsdale, NJ: Erlbaum.

Marks, A. (2001) The Complete Guide to Game Audio: For Composers, Musicians, Sound Designers and Game Developers, Sound/ recording and reproducing/ Digital Techniques, Focal Press.

Marl, K. (1999) The Accessible Games Book. Educational games, Jessica Kingsley Publishers.

Martens, A., Diener, H., and Malo, S. (2008) Game-Based Learning with Computers - Learning, Stimulations, and Games. In Transactions on Edutainment I, Volume 1, Pan, Z., Cheok, A. D., and Muller, W. (Eds.), Springer, 172-190.

Matthews, G., and Zeidner, M. (2004) Traits, States, and the Trilogy of Mind: An Adaptive Perspective on Intellectual Functioning. In Motivation, Emotion, and Cognition: Integrative Perspectives on Intellectual Functioning and Development, Dai, D. Y., and Sternberg, R. J. (Eds.), Lawrence Erlbaum Associates, 143-174.

Maxwell, M., Raney, A. A., Rhodes, N., Dinu, L., Fosu, L., Harriss, C., Zhu, H., and Bryant, J. (2003) Movie Gallery Focus Group: Birmingham, AL. Report to Movie Gallery. Tuscaloosa, AL: Institute for Communication Research.

Mayer, I. (2008) Gaming for Policy Analysis: Learning About Complex Multi-Actor Systems. Why do Game Work?: In Search of the Active Substance, De Caluwe, L., Hofstede, G. -J., and Peters, V. (Eds.), Kluwe, 31-40.

Mayer, R. E. (2001) Multimedia Learning. New York: Cambridge University Press.

Mayer, R. E. (2005) Principles for Managing Essential Processing in Multimedia Learning: Segmenting, Pretraining and Modality Principles (Chapter 11). The Cambridge Handbook of Multimedia Learning, Cambridge University Press, 169-182.

Mayer, R. E., and Moreno, R. (1998) A Split-Attention Effect in Multimedia Learning: Evidence for Dual Processing System in Working Memory. Journal of Educational Psychology, 90, 312-320.

Mayer, R. E., and Moreno, R. (2003) Nine Ways to Reduce Cognitive Load in Multimedia Learning. Educational Psychologist, Lawrence Erlbaum Associates, Inc, 38 (1), 43-52.

Mayer, R. E., and Sims, V. K. (1994) For Whom is a Picture Worth a Thousand Words? Extensions of a Dual-Coding Theory of Multimedia Learning. Journal of Educational Psychology, 84, 389-460.

McAllister, G., and White, G. R. (2010) Video Game Development and User Experience. Evaluating User Experiences in Games: Concepts and Methods, Bernhaupt, R. (Ed.), Springer, 107-128.

McCarthy, J., and Wright, P. C. (2004) Technology as Experience. MIT Press, Cambridge, MA.

McCrindle, R. J. and Symons, D. 92000) Audio Space Invaders. In Proceedings of the Third International Conference of Disability, Virtual Reality and Associated Technologies, Alghero: Italy, 59-65.

McFarlane, A., Sparrowhawk, A., and Heald, Y. (2002) Report on the Educational Use of Games. TEEM (Teachers Evaluating Educational Multimedia). http://www.teem.org.uk.

McGloughlin, S. (2001) Multimedia: Concepts and Practice. Prentice-Hall, Inc, Upper Saddle River, New Jersey, 07458.

McGrath, J. E. (1976) Stress and Behavior in Organizations. In Handbook of industrial and organizational psychology, M. D. Dunnette (Ed.), Chicago: Rand McNally, 1351-1395.

McGregor, J. N., Leplatre, G., Crerar, A., and Benyon, D. (2006) Sound and Soundscape Classiffcation: Establishing Key Auditory Dimensions and their Relative Importance. In Proceedings of the Twelveth International Conference on Auditory Display, June 20-23, 2006, London, UK, 105-112.

McGuire, M. (2009) Creating Games: Mechanics, Content, and Technology. Peters, A.K. Ltd.

McLeod, P., and Posner, M. I. (1984) Privileged Loops from Percept to Act. In Attention and Performance X: Control of Language Process", Bouma, H., and Bouwhuis, D. G. (Eds.), LEA: London, 55-66.

McLuhan, M. (1962) The Gutenberg Galaxy. London: Routledge and Kegan Paul.

Meleis, A. I. (2007) Theoretical Nursing: Development and Progress. Lippincott Williams and Wilkins.

Mendels, P., and Frens, J. (2008) The Audio Adventurer: Design of a Portable Audio Adventure Game. In Proceedings of Fun and Games: Second International Conference, Eindhoven, The Netherlands, October 20-21, 2008, Markopoulos, P., Ruyter, B., and Ijsselteijn, W. (eds), Springer, 46-58.

Mereu, S. W., and Kazman, R. (1997) Audio enhanced 3D Interfaces for Visually Impaired Users. In ACM SIGCAPH Computers and the Physically Handycapped, 57, 10-15.

Microsoft Corporation. (2007) Sound. http://msdn2.microsoft.com/en-us/library/aa511278.aspx [Accessed July 12, 2009]

Miller, G. A. (1956) The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. Psychological Review, 63, 81-97.

Miyashita, H., Takagi, H., Sato, D., and Asakawa, C. (2007) Making Multimedia Internet Contend Accessible and Usable. In Universal Access in Human-computer interaction: Forth International Conference of Universal Access in Human-Computer Interaction, UAHCI 2007, Held as part of HCI International 2007, Beijing, China, July 22-27, 2007, Stephanidis, C. (Ed), Springer, 98-108.

Molich, R., and Nielsen, J. (1990) Improving a Human-Computer Dialogue, Communications of the ACM 33, 3, 338-348.

Montfort, N. (2006) Combat in context. In the International Journal of Computer Game Research, 6 (1).

Moray, N. (1959) Attention in Dichotic Listening: An Effective Cues and the Influence of Instructions. Quarterly Journal of Experimental Psychology, 11, 55-60.

Mountford, S.J. and Gaver, W. (1990) Talking and Listening to Computers. In The art of human-computer interface design, B. Laurel (Ed.), Reading, Massachusetts: Addison-Wesley, 319-334.

Moray, N., Fitter, M., Ostry, D., Favreau, D., and Nagy, V. (1976) Attention to Pure Tones, Quarterly Journal of Experimental Psychology, 28, 271-283.

Morrison, M. (2002) Sams Teach Yourself Game Programming in 24 Hours. Sams Publication.

Murray, J. H. (1998) Hamlet on the Holodeck: The Future of Narrative in Cyberspace, MIT Press, Cambridge.

Musacchia, G., Sam, M., Skoe, E., and Kraus, N. (2007) Musicians Have Enhanced Subcortical Auditory and Audiovisual Processing of Speech and Music. In Proceedings of the National Academy of Sciences of the United States of America, The National Academy of Sciences of the USA (Ed.), 104 (40), 15894-15898.

Mynatt, E.D. (1992) Auditory Presentation of Graphical User Interfaces. In Auditory Display, Sonification, Audifcation and Auditory Interfaces. The Proceedings of the First International Conference on Auditory Display, Santa F Institute, G. Kramer (Ed.), Santa F: Addison-Wesley, 533-555.

Myung, I. J., Kim, C., and Pitt, M. A. (1998) The Power Artifact: Explained. Paper Presented at the Annual Meeting of the Psychonomic Society, Dallas.

N

Naatenen, R. (1973) The Inverted-U Relationship between Activation and Performance: A Critical Review. In Attention and Performance IV, Kornblum, S. (Ed.), New York: Academic Press, 155-174.

Nah, F. H. (2000) A Study of Web Users' Waiting Time. Challenges of Information Technology Management in the 21st Century: 2000 Information Resources Management Association International Conference, Anchorage, Alaska: USA, May 21-24, 2000, Idea group Inc (IGI), 439-441.

Nara, H. (2003) The Foreign Language Learner. In Acts of Reading: Exploring Connections in Pedagogy of Japanese, Noda, M., Brockett, C., Quinn, C. J. (Eds.), University of Hawaii Press, 63-86.

Navon, D. (1977) Forest Before Trees: The Precedence of Global Features in Perception, Cognitive Psychology, 9, 353-383.

Navon, D., and Gopher, D. (1980) Task Difficulty, Resources, and Dual-Task Performance. In Attention and Performance VIII, by Nickerson, R. S. (Ed.), Lawrence Erlbaum Associates, 297-314.

Multimedia Online Expo, NCSA (1995) Virtual Reality: History. http://archive.ncsa.illinois.edu/Cyberia/VETopLevels/VR.History.html [Accessed November 02, 2006]

NCsoft (2007) PlayNC: Games. http://eu.plaync.com/eu/games.

NCsoft (2007) Lineage 2: The chaotic chronicle. http://www.lineage2.com.

Neilsen, L. I., and Sarason, I. G. (1981) Emotion, Personality and Selective Attention. Journal of Personality and Social Psychology, 41, 945-960.

Neisser, U. (1967) Cognitive Psychology, Appleton-Century-Crofts: New York.

Neves, D. M., and Anderson, J. R. (1981) Knowledge Compilation: Mechanisms for the Automatization of Cognitive Skills. In Anderson, J. R. (Ed.), Cognitive Skills and Their Acquisition. Hillsdale, NJ: EWrlbaum, 1-55.

Newell, A. (1973) Production System: Models of Control Structures. In Visual Information Processing, W. G. Chase (Ed.), Academic Press: New York: USA.

Newell, A (1990) Unified Theories of Cognition. Cambridge, MA: Harvard University Press. http://www.soartech.com/htmlonly/technology.soar.html [Accessed October 08, 2010]

Newell, A. F., and Gregor, P. (2000) User Sensitive Inclusive Design - In Search of a New Paradigm. In Proceedings on the 2000 conference on Universal Usability, November 16-17, 2000, Arlington, Virginia, United States, 39-44.

Newell, A., and Rosenbloom, P. S. (1981) Mechanisms of Skill Acquisition and the Law of Practice (Chapter 1). In Cognitive Skills and Their Acquisition, Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey, 1-56.

Newell, A., and Simon, H. A. (1963) GPS, A Program That Stimulates Human Thought. In Computers and thought (pp.279-293), E. A. Feigenbaum, and J. Feldman (Eds.), Cambridge, MA: MIT Press.

Newman, R. (2008) Cinematic Game Secrets for Creative Directors and Producers: Inspired Techniques from Industry Legends, Focal Press.

Newman, W.M. and Lamming, M.G., (1995) Interactive System Design. Addison-Wesley, England.

Ng, B. W. (2007) Video Games in Asia. In The Video Game Explosion: A History from PONG to Playstation and Beyond", Wolf, M. J. P. (Ed.), Greenwood Publishing Group, 211-222.

Nielsen, J. (1993) Usability Engineering. London Academic Press.

Nielsen, J. (1994) Heuristic Evaluation. In Usability Inspection Methods, Nielsen, J., and Mack, R. L. (Eds.), John Wiley and Sons, New York, 25-64.

Falstein, N. and Barwood, H. (2006) The 400 Project. $http://theinspiracy.com/400_project.htm$ [Accessed June 02, 2009]

Nielsen, J., and Molich, R. (1990) Heuristic Evaluation of User Interfaces. In Proceedings of the ACM CHI'90 Conference on Human Factors in Computing Systems, April 1-5 (Seattle, WA: ACM's Special Interest Group of Computer-Human Interaction), 249-256.

Nicotra, G., Bertoni, G., Bortolazzi, E., and Formenti, L. (2010) Innovative Methods for Accessing Mathematics by Visually Impaired Users. In Computers Helping People with Special Needs, Part II: 12th International Conference, ICCHP 2010, Vienna, Austria, July 14-16, 2010, Miesenberger, K. (Ed.), Springer, 423-430.

Nijholt, A., Ruederink, B., and Bos, D. O. (2009) Turning Shortcomings into Challenges: Brain-Computer Interfaces for Games. In Intelligent Technologies for Interactive Entertainment: Third International Conference, INTETAIN 2009, Amsterdamn, The Netherlands, June 22-24, 2009, Nijholt, A., Reidsma, D., and Hondorp, H. (Eds.), Springer, 9, 153-168.

Nikjeh, D. A. (2006) Vocal and Instrumental Musicians: Electrophysiologic and Psychoacoustic Analysis of Pitch Discrimination and Production. PhD Thesis, University of South Florida.

Norman, D. A. (1968) Towards a theory of memory and attention. Psychological Review, 75, 522-536.

Norman, D. A., and Bobrow, D. G. (1975) On Data-Limited and Resource-Limited Processes, Cognitive Psychology, 7, 44-64.

O

Oishi, K., Kamimura, M., Nigorikawa, T., Nakamiya, T., Williams, R. E., and Horvath S. M. (1999) Individual Differences in Physiological Responses and Type A Behavior Patterns. Journal of Physiological Anthropology and Applied Human Science, 18, 101-108.

Okagaki, L., and Frensch, P. A. (1994) Effects of Video Game Playing on Measures of Spatial Performance: Gender Effects in Late Adolescence. Journal of Applied Developmental Psychology, 15(1), 33-58.

Ong, Walter J (1967) The Presence of the Word: Some Prolegomena for Cultural and Religious History, New York: Simon and Schuster.

Organisation for Economic Co-operation and Development, OECD. (2007) OECD in Figures 2007, OECD Publishing.

Orwant, J. (2001) EGGG: The Extensible Graphical Game Generator. Boston, U. S. A: MIT PhD Thesis.

Ossmann, R., and Miesenberger, K. (2008) A Computer Game Designed for All. In Computers Helping People with Special Needs: Eleventh International Conference, ICCHP 2008, Linz, Austria, July 9-11, 2008, Miesenberger, K. (Ed.), Springer, 585-592.

Ossmann, R., and Miesenberger, K. (2010) Accessibility of Social Network Game. In Computers Helping People with Special Needs, Part I: Twelveth International Conference, ICCHP 2010, Vienna, Austria, July 14-16, 2010, Miesenberger, K. (Ed.), Springer, 243-246.

Otjacques, B., Krier, M., Feltz, F., Ferring, D., and Hoffmann, M. (2010) Designing for Older People: A Case Study in a Retirement Home. In HCI in Work and Learning, Life and Leisure: Sixth Symposium of the Workgroup Human-Computer Interaction and Usability Engineering, USAB 2010, Klagenfurt, Austria, November 4-5, 2010. Proceedings, Leitner, G., Hitz, M., and Holzinger, A. (Eds.), 177-194.

Oxford University Press (2007) Compact Oxford English Dictionary: Video Game. $http://www.askoxford.com/concise_oed/videogame$

P

Paas, F., Renkl, A., and Sweller, J. (2003) Cognitive Load Theory and Instructional Design: Recent developments. Educational Psychologist, 38 (1), 1-4.

Page, M., and Moere, A. V. (2007) Evaluating a Wearable Display Jersey for Augmenting Team Sports Awareness. In Pervasive Computing: 5th International Conference, PERVASIVE 2007, Toronto, Canada, May 13-16, 2007, LaMarca, A., Langheinrich, M., and Truong, K. N. (Eds.), Springer, 91-108.

Page, R. M., and Page, T. S. (2003) Fostering Emotional Well-Being in the Classroom, Jones and Bartlett Publisher.

Pagulayan, R. J., Keeker, K., Wixon, D., Romero, R., and Fuller, T. (in press) User-Centered Design in Games. In Handbook for Human-Computer Interaction in Interactive Systems, Jacko, J., and Sears, A. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Pagulayan, R. J., Keeker, K., Wixon, D., Romero, R., and Fuller, T. (2003) User-centered design in games. In Handbook for Human-Computer Interaction in Interactive Systems. Jacko, J., and Sears, A. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Paivio, A. (1986) Mental Representations: A Dual Coding Approach. Oxford, England: Oxford University Press.

Pantev, C., Oostenveld, R., Engelien, A., Ross, B., Roberts, L. E., Hoke, M. (1998) Increased Auditory Cortical Representation in Musicians. Nature 23, 811-814.

Parasuraman, R., and Hancock, P. A. (2001) Adaptive Control of Mental Workload. In Stress, workload, and fatigue, Hancock, P. A., and Desmond, P. A. (Eds.). Lawrence Erlbaum Associates, 305-320.

Pardew, L., Nunamaker, E., Pugh, S., Studios, A., Studios, A., Iverson, B. L., and Wolfley, R. (2004) Games Design for Teens. In Computer games/ Design, Thomson Course Technology.

Park, S. B., and Hwang, H. S. (2009) Understanding Online Game Addiction: Connection between Presence and Flow. In Human-Computer Interaction: Interacting in Various Application Domains: 13th International Conference, HCI International 2009, San Diego, CA, USA, July 19-24, 2009, Jacko, J. A. (Ed.), Springer, 378-386.

Pashler, H. E. (1998) Attention. London: Psychological Press.

Passig, D., and Levin, H. (1999) Gender Interest Differences with Multimedia Learning Interfaces. Computers in Human Behavior, 15, 173-183.

Peissig, J., and Kollmeier, B. (1997) Directivity of binaural noise reduction in spatial multiple noise-source arrangements for normal and impaired listeners, J. Acoust. Soc. Am., 101, 1660-1670.

Peres, S. C., Best, V., Brock, D., Frauenberger, C., Hermann, T., Neuhof, J. G., Valgerdaeur, L., Shinn-Cunningham, B. G., and Stockman, T. (2007). Auditory interfaces. In HCI Beyond the GUI, P. Kortum (ed), Elsevier, In press.
http://cns.bu.edu/ shinn/pages/pdf/AuditoryInterfaces2008.pdf.

Persad, U., Clarkson, P.J. (2005) Characterising Users for Inclusive Design - Three Requirements. In Include 2005, Royal College of Art, London, UK.

Peterson, L.R., and Peterson, M.J. (1959) Short-term retention of individual verbal items. Journal of Experimental Psychology, 58, 193-198.

Pham, T. L., Schneider, G., and Goose, S. (2000) A Situated Computing Framework for Mobile and Ubiquitous Multimedia Access Using Small Screen and Composite Devices. In Proceedings of the Eight ACM international conference on multimedia, New York: USA, 323-331.

Phillips, C. A., Rolls, S., Rouse, A., Griffiths, M. D. (1995) Home Video Game Playing in School Children: A Study of Incidence and Patterns of Play. Journal of Adolescence, 18, 687-691.

Pinelle D, Wong N, Stach T (2008) Heuristic Evaluation for Games: Usability Principles for Videogame Design. In: Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems (Florence, Italy, April 05-10, 2008). CHI '08. ACM, New York, NY, 1453-1462.

Pinker, S. (1997) How the mind works? Penguin, London, UK.

Pintrich, P. R., and Schunk, D. H. (2002) Motivation in education: Theory, research, and applications. (Second Edition). Upper Saddle River, NJ: Merrill, Prentice Hall.

Piselli, P., Claypool, M., and Doyle, J. (2009) Relating Cognitive Models of Computer Games to User Evaluations of Entertainment. In Proceedings of the Forth International Conference on Foundation of Digital Games FDG'09, April 26-30, 2009, Orland: USA, 153-160.

Playfish (2010) Restaurant City. Electronic Arts Inc.
$http://www.playfish.com/?page=game_restaurant$ [Accessed November 02, 2010]

Polit, D. F., and Beck, C. T. (2007) Nursing research: Generating and Assessing Evidence for Nursing Practice. Lippincott Williams and Wilkins.

Pollock, J. (2010) An Architecture for Rational Cognition. A Companion to Epitemology, John Wiley and Sons, 178-185.

Poulton, E. C. (1953). Two-channel listening. J. exp. Psychol, 46, 91-96.

Poulton, E. C. (1956) Listening to Overlapping Calls. J. exp. Psychol, 52, 334-339.

Preece, J. (1994) A Guide to Usability - Human Factors in Computing, Addison Wesley and Open University

Preece, J., Rogers, Y., and Sharp, H. (2002) Interaction Design: Beyond human-computer interaction. Wiley, New York.

Prensky M (2001). Digital Game-Based Learning. New York: McGraw-Hill.

Price, S. (2002) What Sells Where and Why? Lecture Notes from Game Developers Conference Europe.

Puntambekar, A. A. (2009) Software Engineering, Technical Publications.

Q

Qian, L., Zhang, S., and Jin, K. (2010) Strategy Research About Exploiting the Attention Resource of Learners in Educational Games. In Entertainment for Education: Digital Techniques and Systems: 5th International Conference on E-Learning and Games, Edutainment 2010, Changchun, China, August 16-18, 2010, Zhang, X. (Ed.), Springer, 376-384.

Qiu, M. K., Zhang, K., and Huang, M. (2004) An Empirical Study of Web Interface Design on Small Display Devices. In Proceedings of the 2004 IEEE/ WIC/ ACM International Conference on Web Intelligence, Washington DC, USA, 29-35.

Quinn, N., and Holland, D. (1987) Cultural models of language and thought. New York: Cambridge University Press.

R

Rabardel P. (1995) Les Hommes Et Les Technologies : Approche Cognitive Des Instruments Contemporains - d. Armand Colin, Paris, 239.

Rabbitt, P. M. A., and Vyas, S. M. (1980) Looking for One Damn Thing After Another. Manuscript in Preparation.

Rai, D., Beck, J. E., and Heffernan, N. T. (2010) Mily's World: A Coordinate Geometry Learning Environment with Game-Like Properties. In Intelligent Tutoring Systems: 10th International Conference, ITS 2010, Pittsburgh, PA, USA, June 14-18, 2010. Aleven, V., Kay, J., and Mostow, J. (Eds.), Springer, 399-401.

Raisamo, R., Patomaki, S., Hasu, M., and Pasto, V. (2007) Design and Evaluation of a Tactile Memory Game for Visually Impaired Children, Interacting with Computers, 19 (2), 196-205.

Rand, C. S. (1999) I took the medicine you told me, doctor: Self-report of adherence with medical regimens. In The Science of Self-Report: Implications for Research and Practice, Turkkan, J., Kurtzman, H. S., and Cain, V. S. (Eds). Lawrence Erlbaum Associates, 257-276.

Randel, D. M. (2003) The Harvard Dictionary of Music. Harvard University Press, Forth Edition.

Raney, A. A., Smith, J. K., and Baker, K. (2006) Adolescents and the Appeal of Video Games. In "Playing Video Games: Motivates, Responses, and Consequences", Vorderer, P., and Bryant, J. (Ed). Routledge, 165-180.

Rani, P., Sarkar, N., and Liu, C. (2005) Maintaining Optimal Challenge in Computer Games through Real-Time Psychological Feedback. In "Foundations of Augmented Cognition", Schmorrow, D. D. (Ed). Routledge, 184-192.

Rapeepisarn, K., Wong, K. K., Fung, C. C., and Khine, M. S. (2008) The Relationship Between Game Genres, Learning Techniques and Learning Styles in Educational Computer Games. In Technologies for E-Learning and Digital Entertainment: Third International Conference, Edutainment 2008, Nanjing, China, June 25-27, 2008: Proceedings, Pan, Z., Zhang, X., Rhalibi, A. E., Woo, W., and Li, Y. (Eds.), Springer, 497-508.

Razmjou, S. (1996) Mental Workload in Heat: Towards a Framework for Analyses of Stress States. Aviation, Space, and Environmental Medicine, 67, 530-538.

Rehak, B. (2007) Genre Profile: First-Person Shooting Game. In The Video Game Explosion: A History from PONG to Playstation and beyond", Wolf, M. J. P. (Ed.), Greenwood Publishing Group, 187-193.

Resnick, H., and Sherer, M. (1994) Computerized Games in the Human Service - An Introduction. Electronic Tools for Social Work Practice and Education, Resnick, H. (Ed.), Routledge, 11, 5-16.

Revelle, W. (1995) Individual Differences in Personality and Motivation: 'Non-Cognitive' Determinants of Cognitive Performance. In Attention: Selection, Awareness, and Control: A Tribute to Donald Broadbent, Baddeley, A. D., Broadbent, D. E., and Weiskrantz, L. (Eds.), Oxford University Press, 346-373.

Rickard, T. C. (1997) Bending the Power Law: A CMPL Theory of Strategy Shifts and the Automatization of Cognitive Skills. Journal of Experimental Psychology: General, 126, 288-311.

Rigas, D. I., Hopwood, D., and Memery, D. (1999) Communicating Spatial Information Via a Multimedia-Auditory Interface. In 25th EUROMICRO Conference Proceedings, 2, 398-405.

Ritter, F. E., and Reifers, A. L. (2006) Lessons from Defining Theories of Stress. In Integrated Models of Cognitive Systems (IMoCS), Wayne Gray (Ed.), New York, NY: Oxford University Press.

Ritter, F. E., and Schooler, L. J. (2002) The Learning Curve. In International Encyclopedia of the Social and Behavioural Sciences, Amsterdam: Pergamon, 8602-8605.

Ritter, F. E., and Young, R. M. (2001) Embodied models as simulated users: Introduction to this special issue on using cognitive models to improve interface design. International Journal of Human-Computer Studies, 55, 1-14.

Ritterfeld, U. (2009) Introduction. In: Serious Games: Mechanisms and Effects, 3-9, Routledge: New York.

Ritterfeld, U., and Weber, R. (2006) Video Games for Entertainment and Education. In Playing computer games - Motives, Responses, and Consequences, Vorderer, P., and Bryant, J. (Eds.), Mahwah, NJ: Lawrence Erlbaum, 399-413.

Rober, N., and Masuch, M. (2005) Playing Sound-Only Games: A Compendium of Interacting with Virtual, Auditory Worlds. In Proceedings of the 2005 Digital Games Research Conference, Vancouver, British Columbia, Canada.

Roberts, S., and Sternberg, S. (1993) The meaning of additive reaction-time effects: tests of three alternatives. In D. E. Meyer, and S. Kornblum, Attention and performance XIV: synergies in experimental psychology, artificial intelligence, and cognitive neuroscience - a silver jubilee. Cambridge, MA: MIT Press, 611- 653.

Rocker C, Haar M (2006) Exploring the Usability of Videogame Heuristics for Pervasive Game Development in Smart Home Environments. In Proceedings of the Third International Workshop on Pervasive Gaming Applications - PerGames 2006 (Dublin, Ireland, May 7-10, 2006), Springer-Verlag, Heidelberg, 199-206.

Roden, T., and Parberry, I. (2005) Designing a Narrative-Based Audio only 3D game engine. In Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology, ACM, New York: USA, 274-277.

Rodriguez, F., Galvan, F., Ramos, F., and Castellanos, E., Gracia, G., and Covarrubias, P. (2010) A Cognitive Architecture Based on Neuroscience for the Control of Virtual 3D Human Creatures. In Brain Informatics: International Conference, BI 2010, Toronto, Canada, August 28-30, 2010, Springer, 328-335.

Rogers, S. (2010) Level Up!: The Guide to Great Video Game Design. John Wiley and Sons.

Rollings, A., and Adams, E. (2003) Andrew Rollings and Ernest Adams on Game Design. New Riders.

Rosenbloom, P., and Newell, A. (1987) Learning by chunking: A Production System Model of practice. In Production System Models of Learning and Development, MIT Press, 221-286.

Rossing, T. D. (1990) The Science of Sound 2nd Edition, Addison Wesley Publishing Company.

Royal National Institute for the Blind (RNIB, 2011) Supporting Blind and Partially Sighted People. http://www.rnib.org.uk/ [Accessed October 02, 2011]

Rumelhart, D. E. (1980) Schemata: The building blocks of cognition. In R. J. Spiro, B. Bruce, and W. F. Brewer (Eds.), Theoretical Issues in Reading and Comprehension. Hillsdale, NJ: Erlbaum.

Rushby, J. (2001) Modelling the Human in Human Factors. In Udo Voges (Ed.) Computer Safety, Reliability and Security, Twentieth International Conference, SAFECOMP 2001, Budapest, Hungary, September 2001 Proceedings, Springer, 86-91.

S

Saari, T., Turpeinen, M., Kuikkaniemi, K., Kosunen, I., and Ravaja, N. (2009) Emotionally Adapted Games - An Example of a First Person Shooter. In Human-Computer Interaction: Interacting in Various Application Domains: 13th International Conference, HCI International 2009 (HCII 2009), San Diego, CA, USA, July 19-24, 2009, Proceedings, Jacko, J. A. (Ed.), Springer-Verlag: Berlin Heidelberg, 406-415.

Salen, K., and Zimmerman, E. (2004) Rules of Play: Game Design Fundamentals, MIT Press.

Sanchez, J., Baloian, N., and Hassler, T. (2004) Blind to Sighted Children Interaction Through Collaborative Environments. In Groupware: Design, implementation, and use: Tenth International Workshop, CRIWG 2004, San Carlos, Costa Rica, September 5-9, 2004: Proceedings, De Vreede, G. J., Guerrero, L. A., and Raventos, G. M. (Eds.), Springer 2004, 192-205.

Sanchez, J., and Elias, M. (2007) Guidelines for Designing Mobility and Orientation Software for Blind Children. In Human-computer Interaction - INTERACT 2007: Eleventh IFIP TC 13 International Conference, Rio de Janeiro, Brazil, September 10-14, 2007, Proceedings, Part I, Baranauskas, C., IFIP Technical Committee 13 on Human Computer Interaction (Ed.), Springer, 375-388.

Sanchez, J., and Elias, M. (2009) Science Learning in Blind Children Through Audio-Based Games. In Engineering the User Interface: From Research to Practice, Redondo, M., Bravo, C., and Ortega, M. (Eds.), Springer-Verlag: London, 87-102.

Sanger, J., Wilson, J., Davies, B., and Whitakker, R. (1997) Young Children, Videos and Computer Games: Issues for Teachers and Parents, Routledge.

Savidis, A., Grammenos, D., and Stephanidis, C. (2006) Developing Inclusive E-Learning Systems. Universal Access in the Information Society, Special Issue on Information Technology Systems Accessibility, 5 (1), 51-72.

Savidis, A., Stamou, A., and Stephanidis, C. (2007) An Accessible Multimodal Pong Game Space. In Universal Access in Ambient Intelligence Environments: 9th ERCIM Workshop on User Interfaces for All, Konigswinter, Germany, September 27-28, 2006: Revised Papers, Stephanidis, C., and Pieper, M. (Eds.), Springer, 405-418.

Schaffer, N. (2008). Heuristic Evaluation of Games. In Game Usability: Advice from the Experts for Advancing the Player Experience", Isbister, K., and Schaffer, N. (Eds.), Morgan Kaufmann, 79-90.

Schell, J. (2003) Understanding Entertainment: Story and Gameplay are One. In The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. Jacko, J. A., and Sears, A. (Eds.), Routledge, 835-843.

Schell, J. (2008) The Art of Game Design: A Book of Lenses. Morgan Kaufmann, Burlington, MA, First Edition.

Schlaug G, Jancke L, Huang Y, Steinmetz H (1995) In Vivo Evidence of Structural Brain Asymmetry in Musicians. Science, 267, 699-701.

Schmorrow, D. D., Stanney, K. M. And Reeves, L. H. (2006) Foundations of Augmented Cognition (Second Edition). Arlington, VA: Strategic Analysis.

Schneiderman, B. (1992) Designing the User Interface: Strategies for Effective Human-Computer Interaction, Addison Wesley Reading, Massachusetts.

Schneider, E. F., Lang, A., Shin, M., and Bradley, S. D. (2004) Death with a Story: How Story Impacts Emotional, Motivational, and Physiological Responses to First-Person Shooter Video Games. Human Communication Research, 30 (3), 351-375.

Schnotz, W., Boeckheler, J., and Grzondziel, H. (1999) Individual and Cooperative Learning with Interactive Animated Pictures. European Journal of Psychology of Education, 14 (2), 245-265.

Schnotz, W., and Kurschner, C. (2007) A Reconsideration of Cognitive Load Theory. Educational Psychology Review, Springer, Netherlands, 19 (4), 469-508.

Schoenberger, R. W., and Harris, C. S. (1965) Human Performance as a Function of Changes in Acoustic Noise Levels. Journal of Engineering Psychology, 4, 108-119.

Schulze, H. E. (2001) About the Necessity of Memory Training for Blind and Low Vision Seniors and their Training Opportunities in Germany. In the

Special Needs of Blind and Low Vision Seniors: Research and Practice Concepts. Wahl, H. W., and Schulze, H. E. (Eds.), IOS Press, 149-150.

Schuurink, E. L., Houtkamp, J., and Toet, A. (2008) Engagement and EMG in Serious Gaming: Experimenting with Sound and Dynamics in the Levee Patroller Training Game. In Fun n' Games, Markopoulos, P., Ruyter, B. D., and Ijsselsteijn, W. (Eds.), Springer, 139-149.

Schutz, P. A., and Lanehart, S. L. (2002) Emotions in Education: A Special Issue of Educational Psychologist, Routledge, 37 (2).

Scollan, R. (2007) Designing a Pleasurable Interface: Emotion in Human-Computer Interaction. Interaction Design and Information Architecture, University of Baltimore: MD, November 2007.

Screendigest (2004) Press Release: Video Games Market Demonstrates Over 100 Per Cent Growth In Six Years, London, UK, 1 September 2004. http://www.screendigest.com/reports/ils04/press releases 31 08 2004n/view.html [Accessed October 22, 2007]

Sepchat, A., Clair, R., Monmarche, N., and Slimane, M. (2008) Artificial Ants and Dynamical Adaption of Accessible Games Level. Computers Helping People with Special Needs: 11th International Conference, ICCHP 2008, Linz, Austria, July 9-11, 2008, Miesenberger, K. (Ed.), Springer, 593-600.

Shaffer, D. W., Squire, K. R., Halverson, R., and Gee, J. P. (2005). Video games and the future of learning. Phi Delta Kappan, 87 (2), 105-111.

Shallice, T., and Warrington, E.K. (1970) Independent Functioning of Verbal Memory Stores: A Neuropsychological Study. Quarterly Journal of Experimental Psychology, 22, 261-273.

Shallice, T., and Warrington, E. K. (1970) Independent Functioning of Verbal Memory Stores: A Neuropsychological Study. Quarterly Journal of Experimental Psychology, 12, 553-555.

Shapiro, M. A., Herborn, J. P., and Hancock, J. T. (2006) Realism, Imagination and Narrative Video Games. Playing Video Games: Motives, Responses and, Consequences, Vorderer, P., and Bryant, J. (Eds.), Routledge, 323-341.

Shelly, G. B., Cashman, T. J., Vermatt, M. E., and Cashman, J. N. (2000) Discovering Computers 2001 (Chapter 13: Multimedia), Course Technology, Cambridge, Massachusetts.

Shiose, T., Toda, K., Kawakami, H., and Katai, O. (2007) Inclusive design workshop by regional cooperation between an NPC and a university. In

Intercultural collaboration: First international workshop, IWIC 2007, Kyoto, Japan, January 25-26, 2007: Invited and Selected Papers, Ishida, T., Fussell, S. R., Vossen, P. (Eds) Springer, 355-367.

Shneiderman, B. (1992) Designing the User Interface: Strategies for Effective Human-Computer Interaction. Addison-Wesley Reading, Massachusetts.

Shneiderman, B. (2003) Keynote address, HCII 2003 Heraklion, Greece.

Shneiderman, B., Card, S., Norman, D. A., Tremaine, M., and Waldrop, M. M. (2002) CHI@20: Fighting Our Way from Marginality to Power. Chi 2002, 20-25 April, Minneapolis.

Shneiderman, B., Plaisant, C. (2005) Designing the User Interface. Pearson Addison Wesley, Boston.

Shields, M. K., and Behrman, E. (2000) Children and Computer Technology: Analysis and Recommendations. Children and Computer Technology, 10 (2), 4-30.

Shiffrin, R. M. (1975) The Locus and Role of Attention in Memory Systems. In Attention and Performance, Rabbitt, P. M. A., and Dornic, S. (Eds.), Academic Press: New York, 5.

Shiffrin, R. M., and Schneider, W. (1977) Controlled and Automatic Human Information Processing: II. Perceptual Learning, Automatic Attending, and a General Theory. Psychological Review, 84, 127-190.

Shiffrin, R. M., Dumais, S. T., and Schneider, W. (1981) Characteristics of automatism, In Attention and Performance IX, Long, J. and Baddeley, A. (Eds.), 223-237.

Shinn-Cunningham, B. G. (2002) Speech Intelligibility, Spatial Unmasking, and Realism in Reverberant Spatial Auditory Displays. In Proceedings of International Conference on Auditory Displays, Atlanta, GA.

Shinn-Cunningham, B. G., Schickler, J., Kopco, N., and Litovsky, R. (2001) Spatial Unmasking of Hearby Speech Sources in a Simulated Anechoic Environment, J Acoust. Soc Am, 110, 1118-29.

Shinn-Cunningham, B., and Ihlefeld, A. (2004) Selective and Divided Attention: Extracting Information from Simultaneous Sound Sources. In Proceedings of ICAD 04-Tenth Meeting of the International Conference on Auditory Display, Sydney, Australia, July 6-9.

Shumway, A., and Woollacott, M. H. (2007) Motor Control: Translating Research into Clinical Practice. Lippincott Williams and Wilkins.

Sicart, M. (2009) The Ethics of Computer Games, MIT Press.

Simon, D., and Simon, H. (1978) Individual differences in solving physics problems. In Children's thinking: What develops? R. Siegler, (Ed.), NJ: Erlbaum.

Stockholm International Toy Research Center, SITREC. (2005) http://www.sitrec.kth.se [Accessed October 25, 2010]

Smith, B. R. (1999) The Acoustic World of Early Modern England: Attending to the O-Factor. Chicago, IL: University of Chicago Press.

Smith, C. A., and Lazarus, R. S. (1993) Appraisal Components, Core Relational Themes, and the Emotions, Cognition and Emotion, 7, 233-269.

Smith, T. A. (1977). Dynamic Business Strategy: The Art of Planning for Success. Tata McGraw-Hill.

Snyder, M., and Chlan, L. (1999) Music therapy. In Annual Review of Nursing Research: Focus on Complementary Health and Pain Management, Volume 17, 1999, ANNUAL REVIEW OF NURSING RESEARCH", Fitzpatrick, J. J. (Ed.), Springer Publishing Company, 3-26.

Sommer, R. (1983) Social design: creating buildings with people in mind. Prentice Hall: New Jersey.

Southey, F., Xiao, G., Holte, R. C., Trommelen, M., and Buchanan, J. (2005) Semi-Automated Gameplay Analysis by Machine Learning. In "Proceedings of the Twentieth National Conference on Artificial Intelligence and the Seventeenth Innovative Applications of Artificial Intelligence Conference, American Association for Artificial Intelligence, American Association for Artificial Intelligence, Jacobstein, N., Porter, B. (Ed). AAAI Press (ed.), 898-903.

Speelman, C. P., and Kirsner, K. (2005) Beyond the learning Curve: The Construction of Mind. Oxford University Press.

Sperling, G. (1967) Successive Approximations to a Model of Short-Term Memory. Acta psychological, 27, 285-292.

Spuy, R. V. D., and Spuy (2010) AdvancED Game Design with Flash. Apress.

Standen, P. J., and Cromby, J. J. (1996) Can Student with Development Disability use Virtual Reality to Learn Skills which will Transfer to the Real World? In Proceedings of the Third International Conference on Virtual Reality and Persons with Disability, Murphy, H. J. (Ed.), California State University Center on Disabilities.

Steiner, C. M., Kickmeier-Rust, M. D., and Albert, D. (2009) Little Big Difference: Gender Aspects and Gender-Based Adaption in Educational Games.

In Learning by Playing: Game-Based Education System Design and Development: 4th International Conference on E-Learning and Games, Edutainment, Aug 9-11, 2009, Banff: Canada, Chang, M., Kuo, R., and Kinshuk (Eds.), Springer, 150-161.

Stephanidis, C. (2009) The Universal Access Handbook, CRC Press.

Stephanidis, C., and Savidis, A. (2001) Universal Access in the Information Society: Methods, Tools and Interaction Technologies. University Access Inf. Soc., 1, 40-55.

Steuer, J. (1992) Defining Virtual Reality: Dimensions Determining Telepresence, Journal of Communications, 42 (4), 73-93.

Stevens, M. J. (2006) A Transactional Model of Mood. In Mood and Human Performance: conceptual Measurement, and Applied Issues, Nova Science Publisher, Inc., 88-119.

Stichting Bartimeus Accessibility, SBA. (2006) Games People with Visual Disability Play: Audio games. $http://www.gameaccessibility.com/index.php?page_le=visual$ [Accessed December 22, 2006]

Sticht, T. G. (1971) Learning by Listening in Relation to Aptitude, Reading and Rate-Controlled Speech: Additional Studies. Technical report from Education Resources Information Center, 50.

Stokes, A. F., and Kite, K. (2001) On Grasping a Nettle and Becoming Emotional. In Stress, workload, and fatigue, Hancock, P. A., and Desmond, P. A. (Eds.), Mahwah, NJ: L. Erlbaum.

Stolovitch, H. D., and Keeps, E. J. (2002) Telling Ain't Training. American Society for Training and Development.

Sweller, J. (1988) Cognitive Load During Problem Solving: Effects on Learning. Cognitive Science, 12, 257-285.

Sweller, J. (1999) Instructional Design in Technical Areas. Camberwell, Australia: ACER Press.

Sweller, J. (2002) Visualisation and Instructional Design. In Proceedings of the International Workshop on Dynamic Visualizations and Learning (Tubingen, Germany, 18-19 July, 2002). Knowwledge Media Research Center, Tubingen, 2002, 1501-1510.

Sweller, J. (2005). Implications of Cognitive Load Theory for Multimedia Learning. The Cambridge handbook of multimedia learning, Mayer, R. E. (Ed.), New York: Cambridge University Press, 19-30.

Sweller, J. (2010) Cognitive Load Theory: Recent Theoretical Advances. In Cognitive Load Theory, Plass, J. L., Moreno, R., and Bruken, R. (Eds.), Cambridge University Press, 29-45.

Sweller, J., Chandler, P., Tierney, P., and Cooper, M. (1990) Cognitive Load as a Factor in the Structuring of Technical Msaterial. Journal of experimental psychology: general, 119 (2), 176-192.

Sweller, J., and Chandler, P. (1991) Evidence for Cognitive Load Theory. In Cognition and Instruction, Taylor and Francis: London, 8, 351-362.

Sweller, J., Van Merrienboer, J., and Paas, F. (1998) Cognitive Architecture and Instructional Design. Educational Psychology Review, 10, 251-296.

Synder, M., and Chlan, L. (1999) Music Therapy. In Annual Review of Nursing Research, Volume 17, 1999: Focus on Complementary Health and Pain Management, Volume 17; Volume 1999, Fitzpatrick, J. J. (Ed.), 3-25.

T

Tamborini, R., Eastin, M., Skalski, P., Lachlan, K., Fediuk, T., and Brady, R. (2004) Violent Virtual Video Games. Journal of Broadcasting and Electronic Media, 48(3), 335-357.

Targett, S., and Fernstrm, M. (2003) Audio Games: Fun for All? All for Fun? In Proceedings of International Conference on Auditory Display, Boston, MA: USA.

Taylor, A. A., Backlund, P., Engstrom, H., Johannesson, M., and Lebram, M. (2009) Gamers Againsts All Odds. In Learning by Playing: Game-Based Education System Design and Development: 4th International Conference on E-Learning and Games, Edutainment 2009, August 9-11. 2009, Chang, M., Kuo, R., and Kinshuk (Eds.), Springer, 1-12.

Taylor, J. (2006) The Mind: A User's Manual. John Wiley and Sons Ltd., The Atrium, Southern Gate, England.

Tepas, D. I., and Price, J. M. (2001) What is Stress and What is Fatigue? In Stress workload and fatigue. Hancock, P. A., and Desmond, P. A. (Eds.), Mahwah, NJ: LEA.

Tierney, A. T., Bergeson, T. R., and Pisoni, D. B. (2009) General Intelligence and Modality Specific Differences in Performance: A Response to Schellenberg (2008). In Empirical Musicology Review, 4 (1), 37-39.

TiM (2001) The Tim Project, Tactile Interactive Multimedia. http://inova.snv.jussieu.fr/tim [Accessed January 11, 2010]

Thimbleby, H. (1990) User Interface Design, ACM Press Frontier Series, Addison-Wesley, ISBN 0-201-41618-2.

Tol, R. V., Verweij, H., and Huiberts, S. (2002) Drive Research Report. http://www.audiogames.net/drive/research [Accessed September 25, 2006]

Trainor, L. J., and Corrigall, K. A. (2010) Music Acquisition and Effects of Musical Experience. Music Perception, Jones, M. R., Fay, R. R., and Popper, A. N. (Eds.), Springer, 38, 89-128.

Treisman, A. M. (1960) Contextual cues in selective listening, Quarterly Journal of Experimental Psychology, 1, 242-248.

Treisman, A. (1964) Verbal Cues, Language and Meaning in Selective Attention, American Journal of Psychology, 77, 206-214.

Treisman, A. M., and Geen, G. (1967) Selective Attention: Perception or Response?, Quarterly Journal of Experimental Psychology, 19, 1-17.

Treisman, A. M., and Riley, J. G. A. (1969) Is Selective Attention Selective Perception or Selective Response? A further test, Journal of Experimental Psychology, 79, 27-34.

Treisman, A. M., Squire, R., and Green, J. (1974) Semantic Processing in Dichotic Listening? A replication, Memory and Cognition, 2, 641-646.

Tsivian, Y., Taylor, R., and Bodger, A. (1994) Early Cinema in Russia and Its Cultural Reception. Routledge.

Tsuhan, C., and Rao, R. R. (1998) Audio-Visual Integration in Multimodal Communication. In Proceedings of the IEEE, 86 (5), 837-852.

Tulving, E. (1981) Elements of Episodic Memory. Oxford, UK: Clarendon Press.

U

Uden, L. (2003) Designing Hypermedia Instruction. In Designing Instruction for Technology-Enhanced Learning, Rogers, P. L. (Ed.), Idea Group Inc (IGI), 161-183.

V

Vadas, K., Patel, N., Lyons, K., Starner, T., and Jacko, J. (2006) Reading on The-Go: A Comparison of Audio and Hand-Held Displays. In Proceedings of the Eight conference on Human-Computer Interaction with Mobile Devices and Services, ACM, New York: USA, 219-226.

Vallabhaneni, D. (2009) What's Your MBA IQ?: A Manager's Career Development Tool. John Wiley and Sons.

Valentina, R. (2008) Facebook Applications and Playful Mood: The Construction of Facebook as a "Third Place". MindTrek.

Valve (2007) The Orange Box. http://orange.half-life2.com.

Vanderheiden, G. (2000) Fundamental Principles and Priority Setting for Universal Usability. In Proceedings on the 2000 conference on universal usability, Arlington, Virginia: United States, 32-37.

Van Lankveld, G., Spronck, P., Van Den Herik, H., and Rauterberg, M. (2010) Incongruity-Based Adaptive Game Balancing. Advances in Computer Games: Twelveth International Conference, ACG 2009, Pamplona: Spain, May 11-13, 2009, Revised Papers, Van Den Herik, H. J., and Spronck, P. (Eds.), Springer, 208-220.

Vellemen, E., Van Tol, R., Huiberts,S., and Verwey, H. (2004) 3D Shooting Games, Multimodal Games, Sound Games and More Working Examples of the Future of Games for the Blind. Lecture Notes in Computer Science 3118 (January 2004), 257-263.

Verwey, W. B. (1996) Buffer Loading and Chunking in Sequential keypressing. Journal of Experimental Psychology: Human Perception and Performance, 22, 544-562.

Vickery, G., and Organisation for Economic Co-operation and Development (OECD, 2006) OECD Information Technology Outlook 2006. OECD Publishing.

Von Wright, J., and Vauras, M. (1980) Interactive Effects of Noise and Neuroticism on Recall from Semantic Memory. Scandinavian Journal of Psychology, 21, 97-101.

Vorderer, P., Bryant, J., Weber, R., and Pieper, K. (2006) Playing Computer Games as Entertainment. In Playing Computer Games - Motives, Responses, and Consequences, Vorderer, P., and Bryant, J. (Eds.), Mahwah, NJ: Lawrence Erlbaum Associates, 1-7.

Vorderer, P., Hartmann, T., Klimmt, C. (2003) Explaining the Enjoyment of Playing Video Games: The Role of Competition. In Entertainment Comp., ACM: Pittsburgh, 1-9.

W

Waddington, P. (1996) Dying for Information: An Investigation of Information Overload in the UK and World-Wide. London: Reuters Business Information.

Walker, M. H. (2003) Playing the Game - The Fun Factor. Games That Sell! Woodware Publishing, Inc.

Wallen, E., Plass, J. L., and Brunken, R. (2005) The Function of Annotations in the Comprehension of Scientific Texts - Cognitive Load Effects and the Impact of Verbal Ability. Educational Technology, Research and Development, 53, 3, 59-72.

Wang, L., Guo, J, Yang, C., Zhao, H., and Meng, X. (2010) O3D-Based Game Learning Environments for Cultural Heritage Online Education. In Entertainment for Education: Digital Techniques and Systems: 5th International Conference on E-Learning and Games, Edutainment 2010, Changchun, China, August 16-18, 2010, Zhang, X. (Ed.), Springer, 417-428.

Wang, B., Su, M., and Yu, P. (2010) Developing a Multimedia Learning Model Based on Hand-On Learning: A Cognitive Apprenticeship Approach. In Hybrid Learning: Third International Conference, ICHL 2010, Beijing, China, August 16-18, 2010, Tsang, P., Cheung, S. K. S., Lee, V. S. K., and Huang, R. (Eds.), Springer, 259-269.

Wartella, E. A., and Jennings, N. (2000) Children and Computers: New Technology - Old Concerns. Children and Computer Technology, 10 (2), 31-43.

Webster, J. C., and Thomson, P. O. (1953) Some Audio Consideration in Air Control Tower. J. Audio. Engang. Soc., 1, 171-175.

Webster, J. C., and Thomson, P. O. (1954) Responding to Both of Two Overlapping Messages. J. Audio. Soc. Am., 26, 396-402.

Webster, J. C., and Solomon, L. N. (1955) Effects of Response Complexity Upon Listening to Competing Messages. J. acoust. Soc. Am., 27, 1194-1198.

Weisler, S. W., Stillings, N. A., Weisler, S. E., Chase, C. H., Feinstein, M. H., Rissland, E. L., and Garfield, J. L. (1995) Cognitive Science: An Introduction. MIT Press.

Welford, A. T. (1968) Fundamentals of Skill, Methuen: London.

Wenzel, E. M. (1992) Localization in Virtual Acoustic Displays. Presence: Teleoperators and Virtual Environments, 1 (1), 80-107.

Westin, T. (2004) Game Accessibility Case Study: Terraformers - A Real-time 3D Graphic Game. In the Fifth International Conference on Disability, Virtual Reality and Associated Technologies.

West, R. L., Lebiere, C., and Bothell, D. J. (2006) Cognitive Architectures, Game Playing and Human Evolution. In Cognition and Multi-Agent Interaction: from Cognitive Modeling to Social Stimulation, Sun, R. (Ed.), Cambridge University Press, 103-123.

Wickens, C. (1992) Engineering Psychology and Human Performance, Second Edition. New York, HarperCollins.

Wickens, C. D., Gordon, S. E., and Liu, Y. (1998) An Introduction to Human Factors Engineering. Addison-Wesley: New York, NY.

Wickens, C. D., Stokes, A., Barnett, B., and Hyman, F. (1991) The Effects of Stress on Pilot Judgement in MIDIS Simulator. In Time Pressure and Stress in Human Judgment and Decision Making, Svenson, O., and Maule, A. J. (Eds.), New York: Plenum Press, 271-292.

Wilkinson, R. T. (1961) Interaction of Lack of Sleep with Knowledge of Results, Repeated Testing and Individual Differences. Journal of Experimental Psychology, 62, 263 - 271.

Wilkinson, R. T. (1962) Muscle Tension During Mental Work Under Sleep Deprivation. Journal of Experimental Psychology, 64, 565-571.

Williams, D. (2002) Structure and Competition in the U. S. Home Video Game Industry (JJM). The International Journal on Media Management, 4 (1), 41-54.

Williams, L., and Wilkins (2004) Neurosensory System. In NCLEX-RN Review Made Incredibly Easy, Nursing/ Licenses/ United States/ Study guides, 169-214.

Williamson, B. (2003) Accessing Games Through Sound, Motion and Emotion, Tuesday December 23, 2003. http://www.guardian.co.uk/education/2003/dec/23/elearning.technolog [Accessed March 01, 2010]

Wolf, M. J. P., and Perron, B. (2003) The Video Game Theory Reader. New York: Routledge.

Wood, R. T., Griffiths, M. D., Chappell, D., and Davis, M. N. (2004) The Structural Characteristics of Video Games: A Psycho-Structural Analysis. CyberPsychology and Behavior, 7(1), 1-10.

Y

Yelland, N. J. (1999) Reconceptualising Schooling with Technology. Information Technology in Childhood Education, 1(1), 39-59.

Yerkes, R. M., and Dodson, J. D. (1908) The Relation of Strength of Stimulus to Rapidity of Habit Information. Journal of Comparative Neurology of Psychology, 18, 459-482.

Yeung, A. S., Jin, P., and Sweller, J. (1997) Cognitive Load and Learner Expertise: Split-Attention and Redundancy Effect in Reading with Explanatory Notes. Contemporary Educational Psychology, 23, 1-21.

Yost, W. A., Dye, J., Raymond, H., and Sheft, S. (1996) A Simulated Cocktail Party with Up to Three Sound Sources, Percept. Psychophys, 58, 1026-1036.

Yun, R., Jiang, Y., and Li, Y. (2010) Using Computer Games for Youth Development. Transactions on Edutainment III, Pan, Z., Cheok, A. D., Muller, W., and Chang, M. (Eds.), Springer, 253-273.

Z

Zerbst, S., and Duvel, O. (2004) 3D Game Engine Programming. Thomson Course Technology.

Chapter 11

Conference Papers

Creating and Evaluating Accessible Audio-only Games

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ABSTRACT

Audio-only computer games are the primary focus of the present work. They are important for both practical and theoretical reasons. Computer games now form one of the biggest categories of software application in the world. Yet few of them are accessible for those players for whom visual displays are not appropriate, due to circumstances or visual disabilities. Equally, audio-only games provide an environment in which to investigate the psychology of the users of such games. We have deployed both existing games and those designed in collaboration with potential users, noting greater satisfaction with the latter. The objectives of this research were to investigate the psychology of the sound only game by exploring (a) the shape of learning curve and (b) the degree of cognitive overload on users when playing audio-only games. To do so, we have used simple experimental methods. We also explored what makes a truly enjoyable game by measuring our game players' performance and feedback individually.

To date, we have found that game enjoyability relates to an optimum level of cognitive load. We have also found that the so-called universal power law of learning does not always apply and is sometimes replaced by an exponential law that cannot be explained as an artefact of averaging. Different groups of users have been tested i.e. visually impaired people, musicians and sighted people. The visually impaired players tended to improve faster than sighted players, perhaps reflecting higher ability to learn or motivation.

In summary, this work demonstrates the feasibility and acceptability of creating audio-only games plus the importance of the level of cognitive load, the nature of the learning curve, the different design methodologies and the different types of players for an understanding of the psychology of the player of the audio-only computer game.

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http://sites.google.com/site/nordichi2010dc/participants

Keywords

Cognitive overload, learning curves, audio-only games, accessible games design, visual impairment, user experience and needs, and design heuristics.

ACM Classification Keywords

H.5.2 User Interfaces: Auditory (non-speech) feedback.

MOTIVATION FOR THIS RESEARCH

Interactive computer games are growing rapidly and such games now form one of the most popular sources of entertainment in the world today. Computer games are distributed all over the world and it is reported, for example, that most American households play computer or video games as a part of their leisure [7]. Furthermore, computer games have become a major industry with the most popular games selling over a million of copies each and total yearly sales in the range of billions [14].

Given their popularity and attractiveness, computer games have considerable potential for creating positive learning environments, yet most computer games involve graphical interfaces that may only be accessible to sighted users or in specific environments.

Audio-only games represent one significant theme in the development of accessible games, aimed at a very important contribution for anyone with visual disabilities, those whose vision is not a viable option and those who simply like the challenges of audio-only games. On the other hand, arguably, auditory-only presentation may create more cognitive load than the usual combination of audio-visual presentation. They may also be more difficult to learn [11]. These two factors (overload and learning) are the focus of the present research.

Accessibility in computer games design is very important to the extent that it allows different groups of users with different disabilities to play games, or for those who would otherwise be unable to enjoy them fully. However, it is often a difficult and unrewarding task to design and develop an accessible game, as very few such computer games have been developed successfully, specifically games used by disabled users [6]. In particular, users who are blind or who have visual limitations form a substantial group of potentially disadvantaged game players [5, 9]. To develop such games, we perform our research by looking at two well-known sets of findings from cognitive science that have not been established in the context of interactive computer game performance; the two diagnostic measures are the form of the learning curve and cognitive overload. The two performance diagnostic measures are the objectives of this research, and that will help us to explore the designing of a good game. Our suspicion is, however, the traditional laboratory results would not necessarily apply to the interactive gaming context in the same ways as in their original contexts. They have never been reported as such. The typical form of the learning curve is the power law of practice. It is not surprising that performance on most tasks increases with practice. What is surprising is the apparent ubiquity of this power law of practice across diverse tasks and contexts [3, 13, 15]. However, a recent learning curve survey suggests the exponential law of learning as an alternative [10] and that sometimes it may provide a better fit than the power function [12, 16]. This important issue has not yet been thoroughly explored in the context of interactive games.

But will either the power law or exponential law be found in this context? The lab and the game are not identical. At the very least, interactive games should be much more fun than laboratory experiments. If learning follows an exponential curve, then learning reflects a fixed percentage of what remains to be learnt. If learning follows a power law, then learning slows down [15]. If so, the notion of exponential function implies for a truly enjoyable game that could motivate our player to keep playing and learning. So an exponential learning curve may indicate highly motivated players!

We have applied the concept of cognitive overload to the gaming context since we believe that it is not necessarily a negative concept in this context. Perhaps, not all aspects of cognitive overload are bad. It could sometimes be experienced as additional stimulation in a game that protects game performance [4]. If so, the above two diagnostic measures could be used to explore the design of accessible interactive systems and contribute to the attractiveness of a game.

We have also proposed a new cognitive psychology theory [1] with which to guide the design of our audio-only games systematically. This theory is important as it allows designers to retain sufficient complexity in their thinking when understanding important game features. More importantly, this theory is important if it encourages a more thorough approach to understanding our players' psychological requirements, such as their performance and user experience. Such a theory can generate a set of design heuristics from a user model to act as a simple framework that will guide game designers and other practitioners to design enjoyable audio-only games for game users [2].

RESULTS TO DATE

We have found that both of our diagnostic results apply in this context too, a novel result, but in surprising ways. Both the power and the exponential laws apply to audio-only computer games. Cognitive overload does occur, but may actually accompany the increased of satisfaction with a particular game. Also different kinds of users show different learning curves. Perfect-pitch musicians start performance with a positive superiority (higher intercept) that disappears with practice, and that may reflect superior auditory processing skills. Blind players tend to show a steeper learning curve than sighted players that may reflect superior learning or higher motivation. Finally, greater player involvement seems to lead to greater user satisfaction.

GENERAL DISCUSSION

On the basis of our work, we will refine both our evaluation methods and the design of a novel audio-only game. We will also apply the two diagnostics (learning curve and cognitive overload) to caste light on the design of our novel games designs. Additionally, a set of heuristics will be used as a guide to develop an effective audio-only game for a positive user experience. This will help us to monitor and ensure our players' enjoyment when playing such game. Since the explorations of players' learning curves are of practical importance, we should provide them with sufficient exposure to the game in order to effectively evaluate it.

To date, we have gathered different participants, ranging from sighted to blind people to musicians to test our audio-only games. From our analyses, we found that blind users have to rely more on their memory to play the game. Generally, they require a lot of memory power for their daily activities [17]. Perhaps, the memory-rehearsal demands of our games will help them to build stronger working memory skills in everyday life. Sighted people on the other hand are more devoted to visual cues and so, could not easily outperform blind people in audio-only games. Obviously, blind people have stronger auditory perception and performance and so, perform better than any sighted participants.

However, can we compare sighted musicians with blind people in term of auditory perceptual and memory skills in the context of audio-only computer games? How well could a musician with the perfect pitch ability perform when dealing with audio-only games? Clearly, further work to explore the emergence of individual differences would be helpful in order to help generating a clearer insight into the generative of potential interactive computer games.

Future work may afford opportunities to predict and test the shape of the emerging learning curve. We have expected to induce a significant and influential level of cognitive load to support accessible and interactive game playing. As we have deployed both existing games and those designed in collaboration with potential users, it will be possible to compare these approaches with user sensitive design methods. Thus, to date, we have gained some valuable psychological insights into the playing of sound only games.

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REFERENCES

1. Adams, R. (2007) Decision and Stress: Cognition and e-Accessibility in the Information Workplace. Universal Access in the Information Society. 5, 363-379.
2. Adams, R. (2009) User modelling. Invited chapter in "The Universal Access Handbook" Constantine Stephanidis (Ed.,). CRC Press Taylor & Francis Group ?ISBN: 978-0-8058-6280-5 ?June 2009.
3. Alderson, D. L. (2008) Catching the "Network Science" Bug: Insight and Opportunity for the Operations Researcher. Operations Research, 56, 1047-1065.
4. Ang, C. S., Zaphiris, P., and Mahmoud, S. (2007) A Cognitive Model of Cognitive Load in Massively Multiplayer Online Role Playing Games. Interactive with Computers, 19, 167-179.
5. Archambault, D. (2004) The Time Project: Overview of Results. In Computer Helping People with Special Needs: 9th International Conference, ICCHP 2004, Paris, France, July 7-9, 2004: Proceedings, Miesenberger, K., Klaus, J., Burger, D., and Zagler, W. (Eds.), Springer, 248-256.
6. Archambault, D., Gaudy, T., Miesenberger, K., Natkin, S., and Ossmann, R. (2008) Towards Generalised Accessibility of Computer Games. Lecture Notes in Computing Science, 5093, 518-527. Springer: Berlin.
7. ESA (2006) Essential Facts about the Computer and Video Game Industry. Entertainment Software Association.
8. Entertainment Software Association: ESA (2006) Essential Facts about the Computer and Video Game Industry. Entertainment Software Association. http://www.org.id.tue.nl/IFIP-TC14/documents /ESA-Essential-Facts-2006.pdf. [Accessed June, 2010].
9. Furth, B. (2008) Encyclopedia of Multimedia. Springer.
10. Heathcote, A., Brown S., and Mewhort, D. J. K. (2000) The Power Law Repealed: The Case for an Exponential Law of Practice. Psychonomic Bulletin and Review, 7, 185-207.
11. Hinds, P. (1999) Some Cognitive Costs of Video. Media Psychology, 1, 283-311.
12. Josephs, R. A., Silvera, D. H., and Giesler, R. B. (1996) The Learning Curve as a Metacognitive Tool. Journal of Experimental Psychology: Learning, Memory and Cognition, 22, 510-524.
13. Newell, A., and Rosenbloom, P. S. (1981) Mechanisms of Skill Acquisition and the Law of Practice. In J. R. Anderson (Ed.), Cognitive Skills and their Acquisitions. Hillsdale, NJ: Erlbaum, 1-55.
14. Price, S. (2002) What Sells Where and Why? Lecture notes from Game Developers Conference Europe 2002.
15. Ritter, F. E. And Schooler, L. J. (2002) The Learning Curve. In International Encyclopedia of the Social and Behavioral Sciences. 8602-8605. Amsterdam: Pergamon.
16. Rosenbloom, P., and Newell, A. (1987). Learning by Chunking: A Production System Model of Practice. In D. Klahr, P., Langley, and R. Neches (Eds.), Production System Models of Learning and Development. Cambridge, MIT Press, 221-286.
17. Schulze, H.-E. (2001) About the Necessity of Memory Training for Blind and Low Vision Seniors and their Training Opportunities in Germany. On the Special Needs of Blind and Low Vision Seniors: Research and Practice Concepts. Wahl, H.-W., and Schulze, H.-E. (Eds.), IOS Press 2001, 149-150.

Doctoral Colloquium Biography

Tatt Loong Hung is a Chinese who was born in Kuala Lumpur, Malaysia. He received his bachelor degree in Information Technology from Middlesex University London (UK) in 2003. His primary specialization was computing and human-computer interaction (HCI). Here, he studied different types of programming languages to build computer software and applications. In 2005, he graduated a postgraduate course in Computing Science at Middlesex University London (UK). His postgraduate dissertation focuses on the design and development of interactive 3D visual computer games and user experiences.

Hung is currently pursuing a PhD research at Middlesex University London (UK). He work with Dr. Ray Adams and Professor Richard Comley in the School of Engineering and Information Sciences, and is affiliated with the Collaborative International Research Centre for Universal Access (CIRCUA). His current doctoral research focuses at accessibility and usability, dealing with interactive audio-only games design and the enjoyability of computer games for users with visual limitations.

Hung's research interest covers online massively multiplayer online role-playing games (MMORPG), audio perception and processing, individual differences and performance curves. His personal interests include reading, playing computer games, cooking, meditation and playing the piano.